THE

DISSECTION OF THE HUMAN BODY

HOLDEN

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HOLDEN'S ANATOMY

A MANUAL OF THE

Dissection of the Human Body

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SEVENTH EDITION

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IN TWO VOLUMES

VOLUME II

ABDOMEN, LOWER EXTREMITY, BRAIN, EYE, ORGAN OF HEARING, MAMMARY GLAND, SCROTUM AND TESTIS

ILLUSTRATIONS

PHILADELPHIA

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1901

PREFACE TO THE SEVENTH EDITION.

In this edition the editor has carefully revised the entire work, substituted more recent cuts for older ones, and added some additional matter which it is impossible to indicate in the text. The object has been throughout to present the work thoroughly adapted for the use of the students in the dissecting room and for reference by the practitioner. It has been thought well, for the convenience of the former, to divide the book into two volumes. The total number of cuts has not been materially increased, but several new ones have been added from preparations made by the editor.

The editor wishes to acknowledge the work of Dr. Howard Dehoney in the preparation of a portion of the manuscript, Dr. H. L. Bassett in the preparation of the index, and Mr. C. B. Sitgreaves in the preparation of dissections from which some of the new plates were made.

A. H.

1508 Pine Street, Philadelphia.

PREFACE TO THE SIXTH EDITION.

THE chief feature of Holden's Anatomy that must have become apparent to all who have hitherto used it, is not only that the text has been made so concise, but that the subject is presented in as clear and practical a light as is compatible with the faithful handling of its natural difficulties. It gives to the beginner a proper method of procedure, together with such details as are essential to the thorough understanding of the matter in hand. In making this revision the Editor has worked in accord with the editors of the previous editions, and has made such additions and alterations as seemed necessary to bring the book in line with present knowledge and methods, and has added the Metric Measurements side by side with the English. The entire work has been gone over line for line; specially emphasized points have been added in foot-notes to which the editor has signed his initials (A. H.). There are, however, many additions and alterations in the text that were impossible to thus specify.

It has seemed well, in order to reduce the size of the book and still retain its salient features, to put the more minute and intricate points in a smaller type. This will be found an aid to the student and has allowed of the addition of a large number of new illustrations.

The total number of illustrations has been increased from 208 to 311. This, however, does not show the exact number of new pictures, as many of those that appeared in the old editions have been struck out and replaced by more modern ones, taken chiefly from the works of Sappey, Wilson, and Landois.

A. H.

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PREFACE TO THE FIRST EDITION.

If any apology be needed for the appearance of the present Manual, it may be stated, without any wish to disparage the labors of others, that the works of this kind hitherto published seem to the Author open to one or the other of two objections; — either as being too systematic, and therefore not adapted for the dissecting-room, or as obscuring the more important features of Anatomy by a multiplicity of minute and variable details.

In endeavoring to supply a presumed deficiency, the Author has made it his special aim to direct the attention of the student to the prominent facts of Anatomy, and to teach him the groundwork of the science; to trace the connection, and to point out the relative situation of parts, without perplexing him with minute descriptions.

A concise and accurate account is given of all the parts of the human body — the bones excepted, of which a competent knowledge is presupposed — and directions are laid down for the best method of dissecting it.

The several regions of the body are treated of in the order considered most suitable for their examination; and the muscles vessels, nerves, etc., are described as they are successively exposed to view in the process of dissection.

The Author has written the work entirely from actual observations: at the same time no available sources of information have been neglected, the highest authorities, both English and Foreign, have been carefully consulted. His acknowledgments are especially due to F. C. Skey, Esq., F.R.S., Lecturer on Anatomy at St. Bartholomew's Hospital, for many valuable suggestions. He is also much indebted to his young friend, Mr. W. Clubbe, for able assistance in dissections.

September, 1851.

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DISSECTION OF THE ABDOMEN.

Surface Marking. — The body should be sufficiently raised by placing blocks beneath the buttocks and the shoulders, care being taken to have the chest higher than the pelvis.

In the middle line, extending from the ensiform cartilage to the symphysis pubis, is a groove caused by the linea alba, *most marked above the umbilicus,* the line of union of the aponeuroses of the abdominal muscles. In this middle line, nearer the os pubis than the ensiform cartilage, is the umbilicus, which corresponds as a rule with the body of the third lumbar vertebra. The recti muscles can be distinguished on each side of the middle line, and in well-developed subjects, with little fat, the lineæ transversæ may be recognized, the lowest one being at the umbilicus, the highest on a level with the ensiform cartilage, and the third one midway between the two; in muscular subjects a fourth will be found below the umbilicus. On the outer border of the rectus, about three inches (*7.5 cm.*) from the middle line, is a concave line, the linea semilunaris, extending from the ninth or tenth costal cartilage to the spine of the pubis, corresponding to the separation of the aponeurosis of the abdominal muscles to form the sheath of the rectus. Above, and external to the spine of the os pubis, the external abdominal ring can be easily felt, the outer pillar being the stronger; on it rests the spermatic cord passing to the testis. Passing from the spine of the os pubis to the anterior superior spine of the ilium is a crescentic groove which indicates the line of Poupart's ligament, and which can be felt as a firm and slightly curved cord; at about half an inch (*13 mm.*) above the middle of the ligament is situated the internal abdominal ring, which cannot, however, be felt.

Arbitrary Division into Regions. — The abdomen is divided into arbitrary regions, that the situation of the viscera contained in it may be more easily described. For this purpose we draw the following lines: One horizontally across the abdomen on a level with the cartilages of the ninth ribs; another on a level with the anterior superior spines of the ilia. These lines form the boundaries of three spaces, each of which is subdivided into three regions by a vertical line drawn on each side from the cartilage of the eighth rib to the middle of

Poupart's ligament.* Thus, there are a central and two lateral regions in each space. The central region of the upper space is termed the *epigastric;* the central one of the middle space is called the *umbilical* region; and the central of the inferior space, the *hypogastric* region. The lateral regions of the spaces from above downwards are termed the right and left *hypochondriac,* the right and left *lumbar,* and the right and left *inguinal* or *iliac* regions, respectively.

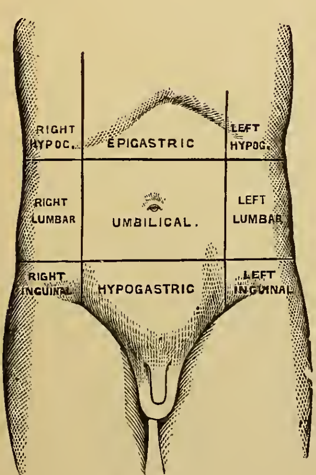


FIG. 154.

The viscera contained in these respective regions are as follows:—

In the *epigastric region* are, the left lobe of the liver, the round ligament of the liver, a small part of the right lobe, the middle and pyloric end of the stomach, the lobulus Spigelii, the pancreas, and the upper border of the transverse colon.

In the *umbilical region* are, the transverse colon, the great omentum and mesentery, the round ligament of the liver, the transverse portion of the duodenum, and part of the jejunum and ileum.

In the *hypogastric region* are, the small intestines, the urachus, the two obliterated hypogastric arteries, the bladder naturally in early life, and in the adult if distended; and, lastly, the uterus in pregnancy.

In the *right hypochondrium* are, the right lobe of the liver, the base of the gall-bladder, the descending duodenum, the hepatic flexure of the colon, pancreas, supra-renal capsule, and the upper part of the right kidney.

In the *left hypochondrium* are, the cardiac end of the stomach, the greater part of the spleen, the tail of the pancreas, the splenic flexure of the colon, the supra-renal capsule, and the upper part of the left kidney.

In the *right lumbar region* are, the ascending colon, the lower part of the right kidney, and small intestines.

* As there are at present fourteen methods of outlining the abdominal superficies, the one herein noted being so universally accepted, the American editor wishes to remind the student that the differences are but trivial. — A. H.

In the *left lumbar region* are, the descending colon, the lower part of the left kidney, omentum, and small intestines.

In the *right inguinal region* are, the cæcum and appendix vermiformis.

In the *left inguinal region* is the sigmoid flexure of the colon.

The abdomen should at this stage be distended with air by means of a blow-pipe inserted into the abdominal cavity through the umbilicus, which, on the removal of the blow-pipe, should be tied with a string to prevent escape of the air.

Dissection. — An incision is to be made from the ensiform cartilage to the os pubis, another from the anterior superior spine of the ilium to a point midway between the umbilicus and os pubis, and a third from the ensiform cartilage, transversely outwards towards the axilla as far as the angles of the ribs. The skin should then be dissected from the subjacent adipose and connective tissue, called the superficial fascia.

Superficial Fascia. — The subcutaneous tissue of the abdomen has the same general characters as that of other parts, and varies in thickness in different persons, according to the amount of fat. At the lower part of the abdomen, it admits of separation into two layers, between which are found the subcutaneous blood-vessels, the lymphatic glands, the ilio-inguinal nerve, and the hypogastric branch of the ilio-hypogastric nerve.

Respecting the superficial layer, observe that it contains the fat, and is continuous with the superficial fascia of the thigh, the scrotum, and the perineum. The deeper layer is intimately connected with Poupart's ligament and the linea alba; but it is very loosely continued over the spermatic cord and the scrotum, and becomes identified with the deep layer of the superficial fascia of the perineum. These points deserve attention, since they explain how urine, extravasated into the perineum and scrotum, readily makes its way over the spermatic cord on to the surface of the abdomen; but from this it cannot travel down the thigh on account of the connection of the fascia with Poupart's ligament.

Superficial Blood-vessels and Lymphatic Glands. — Between the layers of the superficial fascia in the groin and upper part of the thigh are several lymphatic glands and small blood-vessels (Fig. 155). The glands are named, according to their situation, inguinal or femoral. The *inguinal*, from three to four in number, are often small, and escape observation. They are of an oval form, with their long axis corresponding to

the line of the crural arch (represented by the dark line in Fig. 155). They receive the superficial lymphatics from the lower part of the wall of the abdomen, from the integument of the scrotum, penis, perineum, anus, and gluteal region, and are therefore generally affected in venereal disease. The lymphatics from the upper part of the abdominal parietes terminate in the lumbar glands. (Fig. 156, p. 421.)

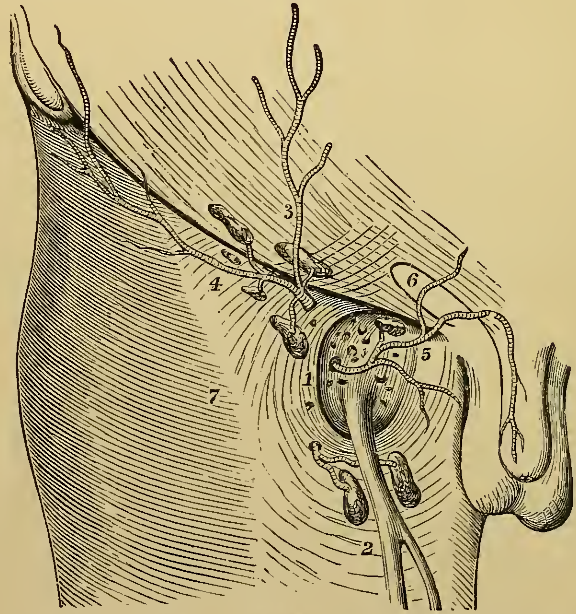


FIG. 155.—SUPERFICIAL VESSELS AND GLANDS OF THE GROIN.

1. Saphenous opening of the fascia lata. 2. Saphena vein. 3. Superficial epigastric a. 4. Superficial circumflexa ilii a. 5. Superficial external pudic a 6. External abdominal ring. 7. Fascia lata of the thigh.

The *superficial arteries* in the neighborhood arise from the femoral. One, the *superficial epigastric*, ascends over Poupart's ligament and ramifies over the lower part of the abdomen, as high as the umbilicus, inosculating with the deep epigastric and internal mammary arteries; another, the *superficial external pudic*, crosses the spermatic cord, and is distributed to the skin of the penis and scrotum, anastomosing with branches of the internal pudic; a third, the *superficial circumflexa ilii*, ramifies towards the spine of the ilium, and communicates with the deep circumflex iliac, the gluteal and external circumflex arteries

These subcutaneous arteries, the pudic especially, often occasion a free hæmorrhage in the operation for strangulated inguinal and femoral hernia.

The corresponding *veins* join the internal saphena vein of the thigh. Under ordinary circumstances, they do not appear in the living subject; but when any obstruction occurs in the inferior vena cava, they become enlarged and tortuoús, and constitute the chief channels through which the blood would be returned from the lower limbs.

Cutaneous Nerves. — The skin of the abdomen is supplied with nerves after the same plan as the chest — namely, by lateral and anterior branches derived from the five or six lower intercostal nerves, as follows: —

a. The *lateral cutaneous nerves* come out between the digitations of the external oblique muscle, in company with small arteries, and divide, except the last, into

FIG. 156. — LYMPHATIC VESSELS AND GLANDS OF THE GROIN.

anterior and posterior branches; the *anterior* pass forwards as far as the rectus, and are distributed to the skin as far as its outer border, and to the digitations of the obliquus externus muscle; the *posterior*, small in size, run backwards, and supply the skin over the latissimus dorsi. The *lateral branch* of the *twelfth thoracic nerve* is larger than the others, and, piercing both the oblique muscles

passes over the crest of the ilium to the skin of the buttock, without dividing like the other nerves. The corresponding branch of the *first lumbar* has a similar distribution.

b. The *anterior cutaneous nerves* emerge with small arteries through the sheath of the rectus. They are not only smaller than the lateral nerves, but their number and place of exit are less regular.

c. The *ilio-hypogastric nerve* comes from the first lumbar nerve, pierces the transversalis at the iliac crest, and then divides into an iliac and hypogastric branch.

The *iliac branch* comes through both oblique muscles, and runs over the crest of the ilium, behind the last thoracic nerve, supplying the integument over the gluteal muscles.

The *hypogastric branch* lies at first between the transversalis and internal oblique; then, piercing the latter, it runs forwards and comes through the aponeurosis of the external oblique, just above the external abdominal ring, and is distributed to the skin in the neighborhood.

d. The *ilio inguinal nerve*, a branch also of the first lumbar nerve, is placed below the preceding nerve, with which it is connected near the crest of the ilium. It pierces the transversalis and internal oblique, runs down in the inguinal canal in front of the cord, and comes out through the external abdominal ring to be distributed to the skin of the inner part of the groin, to the scrotum and penis in the male, and to the labium pudendi in the female.

Dissection. — The deep layer of the superficial fascia should now be removed from the external oblique, by commencing at the fleshy portion of the muscle, and working in the course of its fibres. Care must be taken not to remove any of its silvery aponeurosis, which is very thin, especially above. The digitations of this muscle with the serratus magnus and latissimus dorsi must also be made out.

Muscles of the Abdominal Wall. — The abdominal muscles, three on each side, are arranged in strata, named, after the direction of their fibres, the external oblique, internal oblique, and transversalis. They terminate in front in strong aponeuroses, arranged so as to form a sheath for a broad muscle, called the rectus, which extends perpendicularly on each side the linea alba from the sternum to the os pubis.

External Oblique. — This muscle *arises* from the outer and lower surfaces of the eight or nine lower ribs, by as many pointed bundles, called *digitations*.* The upper five of these interdigitate with similar bundles of the serratus magnus; the three lower correspond in like manner with the origin of the latissimus dorsi; but they cannot be seen unless the body be turned on the side. The upper part of this muscle descends obliquely forwards, and terminates in the aponeurosis of the abdomen; the lower proceeds almost perpendicularly from the

* The upper digitations are attached to the ribs close to their cartilages; the lower ones to the ribs some distance from the cartilages; the last to the apex of the twelfth rib.

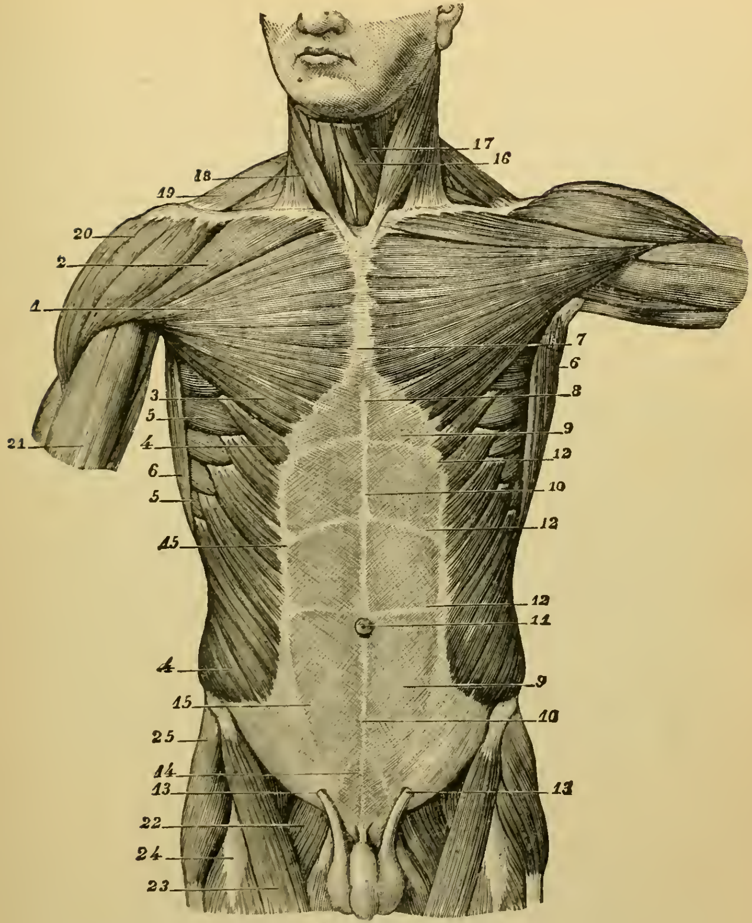


FIG. 157.—MUSCLES OF ANTERIOR PART OF THE TRUNK.

1. Pectoralis major. 2. Its clavicular portion. 3. Fasciculus which is attached to the abdominal aponeurosis. 4, 4. External oblique. 5, 5. Serratus magnus. 6, 6. Anterior border of the latissimus dorsi. 7. Fibrous lamina formed by the interlacing of pectoralis major. 8. Xiphoid appendix. 9, 9. Abdominal aponeurosis. 10, 10. Linea alba. 11. Umbilicus. 12, 12, 12. Linea transversæ. 13, 13. External inguinal opening transmitting the spermatic cord. 14. Pyramidalis abdominis. 15, 15. Border of the rectus abdominis. 16. Sterno-hyoid. 17. Omo-hyoid. 18. Sterno-cleido mastoid. 19. Cervical portion of the trapezius. 20. Delotid. 21. Biceps. 22. Pectineus. 23. Sartorius. 24. Rectus femoris. 25. Tensor vaginæ femoris.

last ribs, and is *inserted* into the anterior half of the outer lip of the crest of the ilium.*

* From its position and the direction of its fibres, it is manifest that the external oblique represents, in the abdomen, the external intercostal muscles of the chest.

The *aponeurosis* of the external oblique increases in strength, breadth, and thickness, as it approaches the lower margin of the abdomen, this being the situation where the greater pressure of the viscera requires the most effective support. Its tendinous fibres take the same direction as the muscle, and form by their decussation in the middle line the *linea alba*, which extends from the ensiform cartilage to the os pubis. Above, the aponeurosis becomes much thinner, and is continued on to the pectoralis major and the ribs. The lowest fibres are strong, and form a thick border, called Poupart's ligament.

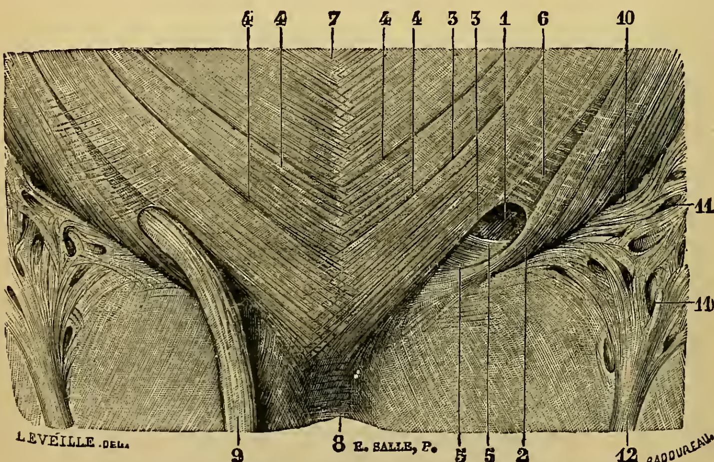


FIG. 158.—POUPART'S LIGAMENT, THE APONEUROSIS OF THE EXTERNAL OBLIQUE AND THE EXTERNAL ABDOMINAL RING.

1. External abdominal ring. 2. Its inferior or external pillar, curvilinear, attached to the spine of the pubis. 3, 3. Its superior or internal straight pillar, prolonged to the median line attached to the symphysis pubis, and interlacing with the one of the opposite side. 4, 4. Ligament of Colles, situated behind the preceding pillar and interlacing with it, attached to the crest of the pubis of the opposite side, thus forming an internal pillar. 5, 5. Attachment of Colles' ligament. 6. Arched fibres connecting the internal and external pillars, forming the external boundary of the ring. 7. Linea alba. 8. Symphysis pubis. 9. Spermatic cord. 10. Poupart's ligament. 11, 11. Cribriform fascia. 12. Internal saphenous vein.

The posterior border of this muscle is fleshy and nearly vertical, and is overlapped in its upper half by the latissimus dorsi.

The aponeurosis is perforated by numerous cutaneous vessels and nerves for the supply of the skin and subjacent tissues; at its lower and inner aspect, close to the spine of the os pubis, there is a large oval opening called the external abdominal ring, transmitting in the male the spermatic cord, and in the female the round ligament.

Poupart's Ligament, or Crural Arch. — Along the line of junction of the abdomen with the thigh, the aponeurosis extends from the anterior superior spine of the ilium to the spine of the os pubis, and forms an arch over the intermediate bony excavation (Fig. 158). This, which is termed the *crural arch*, or, more commonly, *Poupart's ligament*, transmits the great vessels of the thigh, with muscles and nerves.

This ligament, when not separated from its fascial connections, does not run straight from the spine of the ilium to that of the os pubis, but is slightly curved, with its convexity towards the thigh. Above, and somewhat to the outer side of the spine of the os pubis, is situated an opening in the aponeurosis, called the *external abdominal ring*. In the male it is a triangular opening about an inch (*2.5 cm.*) long, with its base at the os pubis, and will admit the passage of a finger; it transmits the spermatic cord. In the female it is smaller, and transmits the round ligament of the uterus. Its direction is downwards and inwards, and it is bounded below by the crest of the os pubis, above by some arched fibres which give strength to the apex of the opening, and on each side by the free margins of the aponeurosis which are termed its columns or pillars. The *inner* or *upper pillar* (No. 3) is thin, and is attached to the front of the os pubis, decussating with its fellow of the opposite side in front of the symphysis. The *outer* or *lower pillar* is thicker and stronger, and has three attachments: one, into the spine of the os pubis — *Poupart's ligament* (No. 10); another, for three-quarters of an inch (*18 mm.*) along the linea ilio-pectinea — *Gimbernat's ligament;* the third — Colles' or *triangular ligament* — consists of a few fibres which pass obliquely upwards and inwards beneath the spermatic cord and the inner pillar as far as the linea alba, where they expand into a triangular fascia in front of the conjoined tendon, and are the lower part of the apoeurosis of the opposite side. At the lower part of the aponeurosis of the external oblique, there are some arched fibres called *intercolumnar fibres,* which are strongest above the external ring. Their use is to strengthen the opening and prevent the ring from enlarging.

Attached to the pillars of the external ring is a thin fascia, the *intercolumnar* or *external spermatic fascia*, which is prolonged over the spermatic cord and testis, and thus forms one of the coverings of that organ.

The spermatic cord in its passage through the ring rests upon the external pillar.

Dissection. — The external oblique should now be detached from the ribs and the crest of the ilium, and turned forwards as far as this can be done without injuring its aponeurosis or the crural arch. In detaching this muscle from the ribs, care should be taken not to reflect with it the upper fibres of the rectus, and as the dissection is carried forwards, the student should avoid injuring the thin aponeurosis of the internal oblique muscle. The second muscular stratum will thus be exposed and recognized by the difference in the direction of its fibres, which run upwards and inwards.

Internal Oblique. — This is thinner than the last-named muscle, and *arises* by fleshy fibres from the outer half or more of Poupart's ligament, from the anterior two-thirds of the middle lip of the crest of the ilium, and from the posterior aponeurosis of the transversalis muscle (fascia lumborum). The fibres radiate from their origin, the anterior ones passing transversely forwards, the posterior ones ascending nearly vertically. The fibres are *inserted* in the following manner: the anterior fibres (which arise from Poupart's ligament) pass inwards, and arch over the spermatic cord, descending somewhat to be inserted, in common with the tendon of the transversalis muscle, into the crest of the os pubis, and for a short distance into the linea ilio-pectinea immediately behind the external ring; the middle fibres (which arise from the anterior iliac spine and front of its crest) are directed transversely inwards, to be attached to an aponeurosis which passes to the linea alba; the posterior fibres ascend nearly vertically to be attached into the cartilages of the four lower ribs, and are continuous with the internal intercostal muscles, which they represent in the abdomen.

Fig. 159. — Diagram of the Lower Fibres of the Internal Oblique and Transversalis, with the Cremaster Muscle.

1. Conjoined tendon of internal oblique and transversalis. 2. Cremaster muscle passing down in loops over the cord.

The aponeurosis of the internal oblique is the broad expanded tendinous tissue into which the muscle is anteriorly attached, and is continued to the middle line, where its fibres join those of the opposite side at the linea alba. It extends from the chest to the os pubis, and its fibres run in the same direction as the muscle. At the outer border of the rectus it splits into

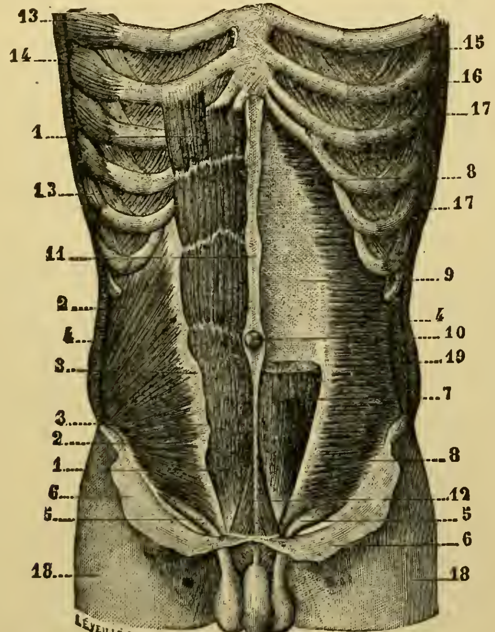


FIG. 160. — DEEP MUSCLES OF THE ABDOMINAL WALL.

1. Rectus abdominis. 2, 2. Internal oblique. 3, 3. Anterior leaflet of the aponeurosis of the internal oblique. 4, 4. Cut external oblique. 5, 5. Spermatic cord. 6, 6. Inferior part of the external oblique aponeurosis turned back on the thigh. 7. Rectus abdominis; the upper part has been excised to show the aponeurosis of the transversalis. 8, 8. Fleshy portion of this muscle. 9. Its aponeurosis. 10. Umbilicus. 11. Linea alba above umbilicus. 12. Infra-umbilical linea alba separating below the two pyramidales. 13, 13. Serratus magnus. 14. Cut right latissimus dorsi. 15. Cut left latissimus dorsi. 16. Cut serratus magnus. 17, 17. External intercostals. 18, 18. Femoral aponeurosis. 19. Cut internal oblique.

two layers — an anterior, which passes in front of the rectus in conjunction with the aponeurosis of the external oblique; and a posterior, which, in common with the aponeurosis of the transversalis, passes behind the rectus. The point of division of the aponeurosis presents a semilunar line extending from the os pubis to the cartilage of the eighth rib. This is called

the *linea semilunaris*, through which a hernia occasionally protrudes. The two layers thus form a sheath for the rectus, which, except at the lower fourth behind, is complete. Midway between the umbilicus and the os pubis, the aponeurosis of all the three muscles pass in front of the rectus, so that posteriorly in this situation it has no sheath. The lower free border of the posterior part of the sheath — the *semilunar fold of Douglas* — marks the situation where the deep epigastric artery enters the substance of the rectus.

Cremaster Muscle. — The *cremaster* is a thin, pale muscle, or the reverse, according to the condition of the subject. It is best to regard it as a detachment of the lowest fibres of the internal oblique, which arise from the middle of Poupart's ligament. Passing along the outer side of the spermatic cord, the fibres descend with it through the external ring, and then arch up again in front of the cord to the spine and crest of the os pubis, forming loops of different lengths, some reaching only as low as the external ring, others lower still, whilst the lowest spread out over the tunica vaginalis of the testis. The muscular fibres are frayed out, being connected by loose cellular tissue, and form a covering for the testis, called the *cremasteric fascia.* This muscle is absent in the female. Its *nerve* comes from the genital branch of the genito-crural, and its artery (*cremasteric*) from the deep epigastric.

Dissection. — The student should not now further dissect the structures on the left side, so that they may be left till a future period for the complete demonstration of the parts concerned in inguinal hernia. On the right side, the internal oblique should be detached from the ribs and the crest of the ilium, and turned forwards, without disturbing that portion of it connected with the crural arch. To avoid cutting away any part of the transversalis in reflecting the internal oblique, dissect near the crest of the ilium, and search for an artery which runs between these muscles, and may be followed as a guide. This artery, called the *deep circumflexa iliac*, is a branch of the external iliac, and supplies the abdominal muscles. Beneath the internal oblique the continuations of the intercostal nerves and vessels are brought into view, as are also the last thoracic, the ilio-hypogastric, and ilio-inguinal nerves near the crest of the ilium. These should be preserved.

The internal oblique is in relation, on its deeper surface with the transversalis abdominis, the fascia transversalis, and with

the spermatic cord near Poupart's ligament; on its inner side, at the division of its aponeurosis, with the outer border of the rectus; below, it forms the upper arched boundary of the inguinal canal.

Transversalis Abdominis. — This muscle *arises* by fleshy fibres from the outer third of Poupart's ligament, from the anterior two-thirds of the inner lip of the crest of the ilium, from a strong fascia attached to the transverse processes of the lumbar vertebræ, and, lastly, from the inner surfaces of the six or seven lower costal cartilages, by digitations which correspond with those of the diaphragm. From this origin the fibres pass horizontally forwards, and terminate anteriorly in a broad aponeurosis attached to its fellow at the linea alba. Some of its lower fibres arch downwards, and are inserted with some

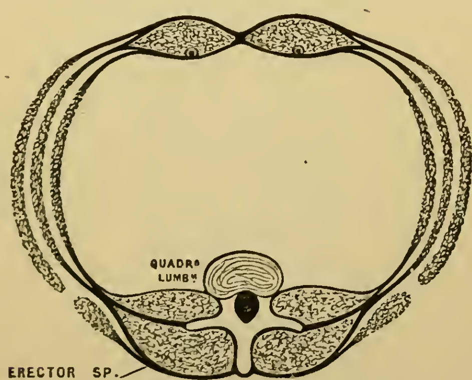


FIG. 161. — TRANSVERSE SECTION THROUGH THE ABDOMINAL MUSCLES TO SHOW THE FORMATION OF THE SHEATH OF THE RECTUS, THE QUADRATUS LUMBORUM, AND THE ERECTOR SPINÆ.

fibres of the internal oblique by means of a conjoined tendon into the crest of the os pubis and the linea ilio-pectinea.

The aponeurosis into which the fibres are inserted is broader below than above, and forms a part of the posterior sheath of the rectus, excepting in the lower fourth, where it passes entirely in front.

In the dissection of the back we have fully described the lumbar fascia, showing that it divides into three layers: the posterior layer, attached to the tips of the spinous processes, gives attachment to the internal oblique, and is continuous with the aponeurosis of the serratus posticus inferior and latissimus dorsi; the middle layer attached to the tips of the transverse

processes, and the anterior layer — very thin — attached to the anterior aspect of the bases of the transverse processes. Between the anterior and middle layer is the quadratus lumborum; between the middle and posterior, the erector spinæ.

Rectus Abdominis. — This long muscle is situated vertically in front of the abdomen, and is enclosed in a sheath formed by the aponeuroses of the lateral muscles of the abdomen, and separated from its fellow by the linea alba. To expose it, therefore, slit up the middle of the sheath, and reflect the two halves. It *arises* by two tendons, the *inner* and *smaller* of which is attached to the front of the symphysis, the *outer* to the crest of the os pubis. As the fibres pass up, the muscle becomes broader and thinner, and is inserted into the fifth, sixth, and seventh costal cartilages. Notice the tendinous intersections across the muscle called *lineæ transversæ*, which are incomplete repetitions of the ribs in the wall of the abdomen.* Their number varies from three to five, but there are always more above than below the umbilicus. These tendinous intersections adhere closely to the sheath in front, but not behind; consequently, pus formed between the front of the rectus and its sheath would be confined by two intersections; not so on the back of the muscle, where pus might travel down the entire length of it. There is one intersection on a level with the umbilicus, one on a level with the ensiform cartilage, and an intermediate one between these two.

The *sheath of the rectus* consists in front of the aponeurosis of the external oblique, and half the thickness of that of the internal oblique; while the back of the sheath comprises the aponeurosis of the transversalis, and half that of the internal oblique (Fig. 161). This, however, applies only to the upper three-fourths of the muscle; the lower fourth has no sheath behind, since all the aponeuroses pass in front of it; the only structure in contact with the muscle in this part is the fascia transversalis.

Pyramidalis. — This small triangular muscle is situated near the os pubis, close to the linea alba, and has a sheath of its own. It *arises* by tendinous fibres from the front part of the os pubis and the anterior pubic ligament in front of the rectus, and terminates in the linea alba about midway between the os pubis and the umbilicus. It is often absent on one or even both sides (Fig. 160, p. 427).

* Some animals, *e.g.*, the crocodile, have bony abdominal ribs.

Linea alba. — The aponeuroses of the abdominal muscles decussate along the middle line and form a white fibrous band, extending from the ensiform cartilage to the os pubis. This is the *linea alba:* it is the fibrous continuation of the sternum, and is broader above than below. A little lower than the middle is a large aperture in it — the *umbilicus* — through which a hernial protrusion not infrequently takes place. It is in relation behind with the fascia transversalis, the urachus, and the bladder when distended.

The linea alba, being the thinnest part of the abdomen, and free from large blood-vessels, is chosen as a safe line for tapping in dropsy, for puncturing the bladder in retention of urine, and for abdominal sections.

Lineæ semilunares. — These are the two slightly curved lines, on the front of the abdomen, corresponding with the outer margins of the two recti muscles. They are formed by the junction of the aponeurosis of the lateral muscles.

The abdominal muscles serve many important purposes: —

Individual Action of Abdominal Muscles. — *Action* of the *external oblique* compresses the abdominal contents in defecation, micturition, parturition, and all expiratory efforts; both external oblique flex the thorax on the pelvis; one acting alone will rotate the pelvis, and on the same side of the thorax this action is assisted by the opposite internal oblique muscle; vertical fibres will produce lateral flexion of the thorax; the pelvis being the fixed point, both muscles will flex the lower thoracic and upper lumbar regions; the *nerves* are the inferior intercostals, after perforating the muscles beneath. *Action* of the *internal oblique* compresses in the same manner as the external muscles; in rotary motions, either will act alone or with the opposite external oblique to rotate the thorax; the thorax being fixed, both ventral and lateral flexion may be accomplished. The *nerves* are, in addition to the inferior intercostals, the ilio-inguinal and ilio-hypogastric from the lumbar plexus.

Action of the *transversalis* muscles, arising as it does from the combined origins and insertions of both external and internal obliques, girths the abdominal cavity, compressing its contents. *Nerves* are the same as the internal oblique. *Action* of the *rectus abdominis,* — it compresses the viscera, assists the external and internal oblique and transversalis muscles, but is particularly active in strong expiratory efforts, as sneezing and coughing. The linea transversæ are remnants of the muscular septa,

which in the lower animals, particularly the crocodile, form abdominal ribs. They increase the strength of the muscles, and prevent ventral hernia. *Nerves* are the inferior intercostals and ilio-hypogastric from the lumbar plexus.

Action of the *pyramidalis* is as a tensor of the linea alba, and assists the rectus muscle. *Nerves* are the eleventh and twelfth intercostals and the ilio-hypogastric. (A. H.)

Collective Action of the Abdominal Muscles. — 1st. *In tranquil expiration* they push the diaphragm upwards by gentle pressure on the abdominal viscera.

In forcible expiration the same process takes place, but with greater energy. This is variously exemplified in coughing, sneezing, and laughing.

2d. *In vomiting*, the diaphragm being fixed * by the closure of the glottis, the abdominal muscles contract, and assist the stomach to expel its contents.

3d. In conjunction with the contracted diaphragm, they assist the muscular walls of the bladder and rectum in the expulsion of urine and fæces, and the action of the uterus in parturition. They exercise a gentle pressure and support on the abdominal viscera, and shield them from injury by strongly contracting when a blow is anticipated.

4th. They are movers of the trunk in various ways. For example, the right external oblique acting with the left internal oblique will rotate the chest towards the left side, as in mowing, and *vice versâ*.

The rectus is chiefly concerned in raising the body from the horizontal position, as anyone may ascertain by placing his hand on the abdomen while rising from the ground. The pyramidalis makes the linea alba tense.

Dissection. — By dividing the rectus transversely near the umbilicus, and raising it from its position, we have a complete view of the manner in which the sheath is formed : we observe, too, that this is absent behind the lower fourth of the muscle. Ramifying in the substance of the muscle is a large artery, called the *deep epigastric*, a branch of the external iliac ; also the continuation of the internal mammary, which descends from the subclavian.

Nerves of the Abdominal Wall. — These nerves are the anterior divisions of the six lower intercostal nerves, and of the

* By the term "fixed," it is meant that the diaphragm forms a resisting surface.

first lumbar. They have the same general course and distribution, and are accompanied by small arteries derived from the intercostal and first lumbar arteries.

The *intercostal* or *abdominal* nerves come forward beneath the anterior extremities of the intercostal spaces, and then run between the internal oblique and transversalis, towards the edge of the rectus, which they enter, small twigs coming through it at the middle line to supply the skin. Each gives off a *lateral cutaneous branch*, which perforates the external intercostal and external oblique muscles, and divides, into an *anterior* branch, distributed to the skin and superficial fascia as far as the rectus, and into a *posterior* branch, smaller than the anterior, which supplies the skin over the latissimus dorsi.

The *last thoracic nerve*, larger than the other intercostals, is continued forwards beneath the last rib, lying on the quadratus lumborum, and then, piercing the transversalis aponeurosis, runs between this muscle and the internal oblique, and is finally distributed like the preceding nerves. Its *lateral cutaneous branch* is very large, and descends over the crest of the ilium.

The *ilio-hypogastric nerve*, a branch of the first lumbar, emerges from the outer border of the psoas, and then runs obliquely across the quadratus lumborum as far as the iliac crest, where it perforates the transversalis muscle and divides into an iliac and an hypogastric branch (p. 422).*

The *ilio-inguinal nerve*, smaller than the former, and, like it, a branch of the first lumbar, runs along the iliac crest after piercing the psoas, and is here connected with the ilio-hypogastric. It comes through the transversalis near the front of the ilium, and, after piercing the internal oblique, runs in front of the cord in the inguinal canal. Its cutaneous distribution has been described (p. 422).

Dissection. — The transversalis muscle must now be reflected with the rectus by incisions similar to those for the reflection of the external oblique, when a thin delicate fascia behind, the *fascia transversalis*, will be exposed. The dissection should take place from below upwards, as the muscle is less intimately connected with the fascia below than it is higher up.

* The ilio-hypogastric and ilio-inguinal nerves form important landmarks in operating upon the kidney, as the former crosses the perinephritic fat obliquely from within outwards and appears in the wound before the organ is reached. The latter nerve crosses the kidney lower than the former. — A. H.

Fascia Transversalis. — This fascia separates the transversalis muscle from the peritoneum, and is so called because it lies in contact with the posterior surface of the muscle. It is comparatively thin, superiorly, where it is continuous with the fascia on the under surface of the diaphragm. Inferiorly, it is thick and strong, and is attached to the crest of the ilium and to Poupart's ligament, where it is strengthened by fibres from the aponeurosis of the transversalis; it becomes continuous with the fascia covering the iliacus muscle (iliac fascia), and below with the pelvic fascia. About the middle of Poupart's ligament it sends a funnel-shaped prolongation downwards into the thigh, forming the anterior part of the sheath of the femoral vessels. Internally, it is connected with the margin of the rectus, to the lower margin of the conjoined tendon, to the os pubis, and to the pectineal line. This fascia is strongest just behind the external abdominal ring, and, but for it and the conjoined tendon, there would be a direct opening into the abdominal cavity through the external ring. The outer half of the fascia is very firmly connected to Poupart's ligament and to the fascia iliaca; but the inner half is loosely connected with the crural arch, and passes down under it, as before stated, over the femoral vessels into the thigh, and forms the front of what is termed the crural sheath.*

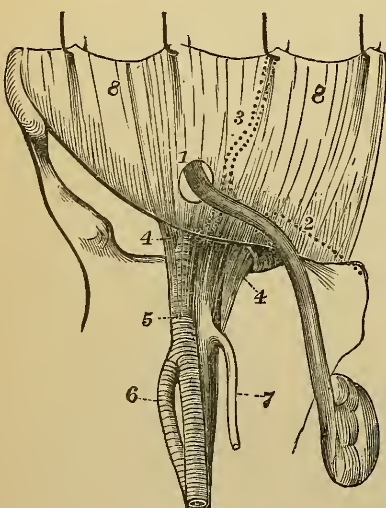


Fig. 162. — Diagram of the Fascia Transversalis, seen from the Front.

1. Internal abdominal ring. 2. Position of the external abdominal ring in dotted outline. 3. Epigastric a. in dotted outline. 4, 4. Sheath of the femoral vessels, continued from the fascia transversalis. 5. Femoral a. 6. Profunda a. 7. Saphena v. 8, 8. Fascia transversalis.

Internal Abdominal Ring. — The opening in the fascia transversalis through which the spermatic cord passes is called the *internal abdominal ring* (or the inner aperture of the inguinal canal).

* The femoral sheath is formed by the fasciæ from the iliacus, transversalis and the obturator internus muscles. Thus making a funnel-shaped process in which is lodged the femoral vessels, and a space in which the hernia may take place. — A. H.

It corresponds to a point midway between the anterior superior spine of the ilium and the spine of the os pubis, and about half an inch (*13 mm.*) above Poupart's ligament. It is oval with the long diameter nearly vertical; it is bounded above by the arched fibres of the transversalis muscle, and on the inner side by the deep epigastric vessels. Its margin is well defined on the inner, but not on the outer side, and from its border is continued forwards a funnel-shaped prolongation over the spermatic cord, which passes through the ring. This covering, thin and delicate, is termed the *infundibuliform fascia.* (This is not seen in the diagram). Close by the inner border of the internal ring, the deep epigastric artery ascends to enter the substance of the rectus.

Arteries of the Abdominal Walls. — The abdominal walls are supplied with blood derived from the intercostal, lumbar, and deep circumflex iliac arteries, and in front also, from the internal mammary and deep epigastric arteries.

The *intercostal arteries* come from the descending thoracic aorta, and, like their accompanying nerves, enter the abdominal wall between the transversalis and internal oblique muscles. They anastomose with the internal mammary, deep epigastric, and lumbar arteries.

The *lumbar artery* accompanies the last thoracic nerve.

The *internal mammary artery* divides, between the cartilages of the sixth and seventh ribs, into the musculo-phrenic and the superior epigastric arteries. The superior epigastric artery descends behind the cartilage of the seventh rib, and, piercing the sheath of the rectus, enters that muscle, supplying it and anastomosing with the deep epigastric.

The *musculo-phrenic artery* descends obliquely outwards behind the cartilages of the false ribs, and pierces the diaphragm about the ninth rib; it is then continued along the last intercostal space, and terminates in branches for the supply of the abdominal walls.

The *deep epigastric artery* arises from the external iliac, just before this vessel passes under the crural arch to take the name of femoral. It ascends inwards between the fascia transversalis and the peritonium, forms a gentle curve on the *inner side* of the internal abdominal ring, and consequently on the inner side of the spermatic cord, and then enters the rectus muscle just below the fold of Douglas, which is the lower arched edge of the posterior sheath of the rectus.

The artery runs in the substance of the rectus parallel with the linea alba, and inosculates with the superior epigastric branch of the internal mammary artery. It is accompanied by two veins, of which the larger is on its inner side ; these terminate in a single trunk in the external iliac vein.

The deep epigastric gives off the following branches : —

The *pubic* is the most important branch. It runs inwards behind the crural arch towards the os pubis, behind which it anastomoses with the pubic branch of the obturator. Sometimes the obturator artery is absent or small, in which case the pubic branch of the epigastric enlarges and takes the place of the absent vessel. It derives its chief practical interest from the fact that it is liable to be wounded in dividing the stricture in femoral hernia. But its size varies in different subjects, and is sometimes so small as to escape observation. The second branch is the *cremasteric.* It supplies the coverings of the cord, but chiefly the cremaster muscle. After giving off other unnamed *muscular branches*, some of which perforate the mnscle to supply the skin, the main trunk terminates in the rectus by inosculations with the internal mammary.

Deep Circumflex Iliac. — The *deep circumflex iliac* artery is a branch of the external iliac, just above the crural arch ; it runs upwards and outwards, behind and parallel with Poupart's ligament, and at the middle of the crest of the ilium pierces the transversalis muscle, and, running in the same direction, lies between the transversalis and internal oblique. It anastomoses with the ilio-lumbar artery, and sends small muscular branches, which run upwards, and communicate with the epigastric and the lumbar arteries.

The circumflex iliac veins join to form a single *vein*, which crosses the external iliac artery, and opens into the external iliac vein.

Dissection. — To see that part of the peritoneum concerned in inguinal hernia, the fascia transversalis must be removed by incisions similar to those recommended before. The fascia is easily separable from the peritoneum, which is situated immediately behind it, owing to the presence of more or less fat — *subperitoneal fat.* The peritoneum at the inner ring presents a well-marked depression, which varies, however, considerably, in some being scarcely visible, in others being continued downwards into the inguinal canal, in the form of a pouch. In some instances, a communication is found between the general cavity of the peritoneum and the tunica vaginalis testis.

Inguinal Canal. — Having examined the several strata through which the spermatic cord passes, replace them in their natural position, and examine the inguinal canal as a whole. Its

direction is obliquely downwards and inwards. Its length in a well-formed adult male is from one and a half to two inches (*3.8 to 5 cm.*). It commences at the inner ring, and terminates at the external abdominal ring. It is bounded *in front* by skin, superficial and deep fasciæ, by the aponeurosis of the external oblique, and externally by a small portion of the internal oblique ; *behind*, by the fascia transversalis, by the conjoined tendon of the internal oblique and transversalis, and by the triangular ligament; *above*, by the lower fleshy fibres of the internal oblique and transversalis ; *below*, by the junction of the fascia transversalis with the crural arch.

Spermatic Cord. — This round cord extends from the testis to the internal abdominal ring, and consists of numerous structures, connected together by delicate areolar tissue, and is surrounded by the different strata from the abdominal muscles, which are pushed down in the descent of the testis into the scrotum in fœtal life. The cord lies in the inguinal canal; at the outer ring it rests on the outer pillar, and at the inner ring the different constituents of the cord separate from each other.

The *arteries of the cord* are derived from the spermatic artery from the abdominal aorta, the deferential artery from the superior vesical, and the cremasteric branch from the deep epigastric.

The *veins of the cord* are chiefly the spermatic: they form on the cord a plexus of veins — the *pampiniform plexus* — and, passing up in front of the cord, open on the right side into the inferior vena cava; and on the left side, into the left renal-vein.

The *lymphatics* pass into the lumbar glands.

The *nerves* are derived from the renal, aortic, and hypogastric plexuses. In front of the cord is the ilio-inguinal nerve, and behind it is the genital branch of the genito-crural nerve.

The cord, as will presently be described, receives coverings from the external oblique, from the internal oblique and transversalis, and from the fascia transversalis.

The *vas deferens*, the excretory duct of the testis, passes through the inguinal canal, being placed behind the other constituents of the cord, and after passing through the inner ring, curves round the epigastric artery in its descent into the pelvis.

Round Ligament. — In the female there is a round cord occupying the inguinal canal — the *round ligament* — which is lost, external to the outer ring, in the subcutaneous tissues of

the labium majus. Its coverings are the same as those of the male, excepting the cremasteric fascia.

Deep Crural Arch. — This structure, which is apparently a thickening of the fascia transversalis, has more to do with femoral hernia, and its description will, therefore, be deferred until this form of hernia is considered in the dissection of the thigh.

DISSECTION OF THE PARTS CONCERNED IN INGUINAL HERNIA.

Dissection. — The student has now completed the dissection on the right side, and, having mastered the general anatomy of this region, he may pass on to the special consideration of the anatomy of inguinal hernia. If the instructions before given have been duly observed, the left side is available for this purpose ; and although it may be well that the dissector (especially for the first time) should have the advantage of the parts being made clear by his demonstrator, there is no real difficulty in making out the different layers which constitute the coverings of a hernia, or the various parts through which a hernia travels.

It will be remembered that on the left side the dissection has been carried as far as the exposure of the internal oblique and cremaster. An incision must now be made through the *external oblique*, from a point midway between the umbilicus and the os pubis, transversely outwards to the anterior superior iliac spine, and another from the same point downwards in the middle line through the linea alba as far as the symphysis pubis. When this flap has been turned downwards, the dissector will see that it is aponeurotic, and he can take the opportunity of making out the external abdominal ring and the external spermatic fascia which is prolonged downwards from the pillars of the ring, as also the intercolumnar bands which strengthen the upper part of the ring.

The *internal oblique* now comes into view, and its origin from Poupart's ligament must be carefully made out, together with the cremaster muscle, which loops in front of the cord, and which can be seen coming under the arched fibres of this muscle. Next, the internal oblique should be reflected from Poupart's ligament and the iliac crest by a transverse incision to the extent of that through the external oblique. The flap should then be reflected inwards, care being taken not to reflect with it the sub-

jacent muscle (transversalis); this may be prevented by looking for a branch of the deep circumflex iliac artery, which runs along the crest of the ilium between these muscles. The turning back of this muscle exposes the transversalis, which in its turn will be reflected inwards in the same manner. The inner parts of both these muscles are intimately connected by a common tendon, called the *conjoined tendon*, inserted in front of the rectus into the crest of the os pubis and the pectineal line. Observe that this tendon lies immediately behind the external abdominal ring, and that it varies in thickness in different subjects. The arching over of the lower fibres of the internal oblique and transversalis, so as to form the upper boundary of the inguinal canal, is now well seen.

Reflect the *transversalis* exactly in the same way as the internal oblique, when the fascia transversalis comes into view, presenting the funnel-shaped prolongation of fascia — *infundibuliform* — which is continued over the cord and testis.

The *transversalis fascia* should now be detached from the subjacent peritoneum, in front of which is more or less fat (*subperitoneal*), and turned down, when the internal abdominal ring becomes apparent, with its well-defined inner margin.

During the reflection of these successive muscles, the student will have been enabled to recognize the strata which are prolonged from them: viz., from the external oblique is derived the *spermatic fascia;* from the internal oblique and transversalis is derived the *cremasteric fascia;* and from the fascia transversalis is prolonged the transversalis fascia, which here takes the name of the *infundibuliform fascia.*

The extent and boundaries of the inguinal canal and the relation of the epigastric artery to the inner ring can now be clearly defined; and if the dissector passes his little finger into the internal abdominal ring, down the canal and out through the external ring, he will easily see that it carries before it the three strata previously described, which constitute not only the coverings of the cord, but likewise the coverings* of an oblique inguinal hernia, when this exists.

Practical Application. — The testis, originally formed in the loins, passes, about the eighth month of fœtal life, from the abdomen into the scrotum, through an oblique canal in the wall of the abdomen, called the inguinal canal. A portion of peritoneum

* In the case of a hernia there is necessarily in addition a covering of subperitoneal fat, and of peritoneum which forms the sac.

is pouched out before the descending testis, and constitutes the tunica vaginalis testis. The blood-vessels, nerves, and vas deferens are drawn down with the testis, and constitute the spermatic cord. The inguinal canal runs obliquely through the abdominal wall, that it may the better resist the protrusion of intestine.

The wall of the abdomen, as previously stated, is composed of various strata, and the testis and cord in their passage through each stratum derive from each a covering similar in structure to the stratum itself. Of these strata there are three: the first, proceeding from within outwards, is the *fascial stratum* derived from the fascia transversalis; the second is the *muscular stratum* (cremasteric) from the internal oblique and transversalis muscles; the third is the *aponeurotic stratum* from the external oblique.

The passage of the testis through the lower part of the abdominal parietes (inguinal canal) occasions, at this part of the belly, a natural weakness which, associated with other conditions, favors the protrusion of intestine in this situation.

A protrusion of intestine through any part of the inguinal canal is called an *inguinal hernia:* of which two chief varieties exist, the *indirect* or *oblique*, and the *direct;* the former protruding to the outer side of the deep epigastric artery; the latter coming out to the inner side of the artery.

Oblique Inguinal Hernia. — The most common form of inguinal hernia is that in which a portion of intestine protrudes first through the internal ring, then, traversing the inguinal canal, emerges through the external ring, and thence may descend into the scrotum. This variety is called an *oblique inguinal hernia.** If the intestine stops within the inguinal canal, it is called an *incomplete inguinal hernia;* if, however, the protrusion has emerged through the external ring, it is called a *complete inguinal hernia;* and, lastly, if it descends into the scrotum, it is called a *scrotal hernia.*

Coverings of an Oblique Inguinal Hernia. — A *complete* oblique inguinal hernia, passing as it does through the same structures as the testis did in fœtal life, receives the same coverings as that gland; they are:—

1. The *skin* and the *superficial fascia.*
2. The *intercolumnar fascia* derived from the external oblique.

* A hernia is sometimes called *external* or *internal*, according to the relation of the protrusion to the deep epigastric artery: thus, an oblique inguinal hernia which first protrudes through the inner ring is called an *external hernia*, and *vice versâ.*

3. The *cremaster*, derived from the internal oblique and transversalis.*

4. The *infundibuliform fascia*, derived from the fascia transversalis.

5. The *subperitoneal fat* and the *peritoneum* which constitutes the sac.

An *incomplete* oblique inguinal hernia is covered by —

1. The *skin* and *superficial fascia.*
2. The *aponeurosis* of the *external oblique.*
3. The *cremaster.*
4. The *infundibuliform fascia.*
5. The *subperitoneal fat* and the *peritoneum.*

Direct Inguinal Hernia. — The intestine, however, does not always escape through the internal ring. Sometimes it protrudes *internal* to the deep epigastric artery through a triangular weak place, *Hesselbach's triangle*, bounded on the inner side by the rectus, on the outer side by the deep epigastric artery, and below by Poupart's ligament. This space is relatively weak, having in front of it only the fascia transversalis and the conjoined tendon of the internal oblique and transversalis; moreover, it is situated immediately behind the external abdominal ring. A portion of intestine protruding through this triangle comes directly forwards through the external ring, and the hernia is then called a *direct inguinal hernia.*

Coverings of a Direct Inguinal Hernia. — A *direct* inguinal hernia protrudes immediately on the inner side of the epigastric artery through the external ring; and its course forwards is mainly prevented by the resistance of the conjoined tendon.† This hernia is covered by —

1. The *skin* and *superficial fascia.*
2. The *intercolumnar fascia.*‡
3. The *conjoined tendon* of the internal oblique and transversalis.
4. The *fascia transversalis.*
5. The *subperitoneal fat* and the *peritoneum.*

* The cremaster muscle is absent in the female.

† In our experience the weakness of the conjoined tendon is, anatomically speaking, the determining cause of this form of hernia.

‡ As the cremasteric fascia or muscle is already present outside the external abdominal ring, it should be enumerated as one of the coverings in direct hernia as well as in oblique. — A. H.

A direct hernia, as has been said, emerges through Hesselbach's triangle, and if this triangle be viewed from its deeper aspect, it will be seen that, usually, the obliterated hypogastric artery corresponds in its course to the deep epigastric artery. Occasionally, however, it is placed further inwards, so that it divides the triangle into two smaller ones, in both of which there is a shallow pouching of peritoneum. Now, if a direct hernia protrudes through the outer of these two smaller triangles, it descends through the inguinal canal, and thus will have all the coverings of an ordinary oblique inguinal hernia.

In almost all cases, the immediate investment of the intestine is the parietal layer of the peritoneum. This constitutes the

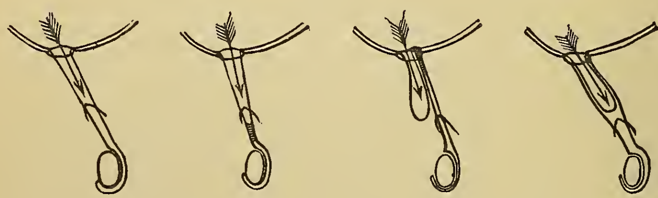


FIG. 163.—VARIETIES OF CONGENITAL INGUINAL HERNIÆ, CONSEQUENT UPON SOME DEFECT IN THE DEVELOPMENT OF THE SPERMATIC PORTION OF THE TUNICA VAGINALIS. THE ARROWS MARK THE PROTRUSION.

1. Hernia in the tuiuca vaginalis testis. 2. Hernia in the funicular portion of the tunica vaginalis. 3. Infantile hernia. 4. Encysted hernia.

sac of the hernia. The opening of the sac, communicating with the abdomen, is called its *mouth;* then comes the narrow, constricted portion, or *neck ;* and lastly, the *body,* or expanded part of the sac.

Congenital Hernia. — Owing to the comparatively late descent of the testis in fœtal life, it frequently happens that either no closure, or only a partial closure, takes place in the vaginal portion of the tunica vaginalis. Under these conditions, when a protrusion takes place, the intestine does not push forwards a sac derived from the parietal layer of the peritoneum, but it lies in a sac formed by the tunica vaginalis, which still communicates with the peritoneal cavity. These herniæ are always oblique, and are termed *congenital.** There are four

* The term *congenital* applied to this form of hernia is apt to suggest the idea that it occurs at birth. But this is not of necessity so. Although the state of parts favorable to its occurrence exists at birth, the hernia itself may not take place till many years afterwards — in fact, at any period of life.

varieties, all of which are the result of, or associated with, some congenital defect. They are as follows : —

1. *Hernia* in the *tunica vaginalis testis.* — This occurs when a protrusion of intestine takes place through the narrow canal which persists between the general cavity of the peritoneum and the tunica vaginalis testis, in consequence of the non-obliteration of the original communication between them. In this case the intestine surrounds the testis, and the sac is formed by the tunica vaginalis testis (Fig. 163, 1).

2. *Hernia* in the *funicular portion* of the *tunica vaginalis* occurs when an incomplete closure of the tunica vaginalis takes place immediately above the testis; the canal above it being still unclosed and communicating with the peritoneal cavity. The sac is formed by the original pouch of the peritoneum in the descent of the testis, although shut off from the tunica vaginalis testis by a thin septum (Fig. 163, 2).

3. *Infantile hernia* is rare, and occurs when the original peritoneal canal is occluded at the inner ring, so that the tunica vaginalis testis reaches up as high as the canal, or even as far as the internal ring. The intestine in this variety protrudes a sac through the inner ring, but behind this abnormal extension of the tunica vaginalis; so that in front of the hernia there are three layers of peritoneum: two formed by the tunica vaginalis, the third by the sac (Fig. 163, 3).

4. *Encysted hernia* is still rarer than the preceding, and may occur in those cases in which the closing septum at the internal ring is so thin that an advancing hernia pushes before it this thin stratum (which forms its sac) as a diverticulum into an unclosed tunica vaginalis (Fig. 163, 4).

Position of Spermatic Cord. — The spermatic cord is generally situated behind and to the outer side of a hernial sac. In some cases, however, the hernia separates the constituents of the cord, so that one or the other of these comes to lie in front of the protrusion.

Seat of Stricture. — The stricture may be seated either at the external ring, the internal ring, at any intermediate part between these, or at the neck of the sac. Sometimes there is a double stricture, one at the external ring, the other at the internal.

As stated, the stricture may be caused by the neck of the sac, independently of the parts outside it; for the peritoneum may become thickened and indurated, and sufficiently unyielding to strangulate the protruded intestine. The strangulation in a congenital hernia is nearly always caused by the neck of the sac itself.

In dividing the stricture, the surgeon should, in all cases, adhere to the golden rule laid down by Sir Astley Cooper — namely, to divide it directly upwards. In this direction there is the least likelihood of wounding the deep epigastric artery.

Changes Produced by an Old and Large Hernia. — Whoever has the opportunity of dissecting an old hernia of some size, will observe that the obliquity of the inguinal canal is destroyed.

The constant dragging of the protruded viscera upon the inner margin of the internal ring gradually approximates the internal ring to the external, so that at last the one gets quite behind the other, and there is a direct opening into the abdomen. But the position of the deep epigastric artery with regard to the sac remains unaltered. It is still on the *inner side* of the neck of the sac.

In a hernia of long standing, all its coverings undergo a change. They become thickened and hypertrophied, and so altered from what they once were that they scarcely look like the same parts.

Umbilical Hernia. — This is a hernia which protrudes through the umbilical opening in the middle line at the umbilicus, and is most commonly met with in infant life, and in the female sex in advanced life, especially in obese subjects. The hernia is frequently large, and, in its enlargement, it increases in an upward direction, so that the aperture, through which it comes, is not in the centre of the hernia.

Its coverings are skin, subcutaneous fat and connective tissue, a thin fascia which covers in the umbilical aperture, fascia transversalis, subperitoneal fat, and peritoneum.

The seat of strangulation in this variety of hernia is the fibrous margin of the umbilical aperture. This must be divided, and, as there are no vessels or other structures of importance near it, the margin may be divided at any part most convenient to the operator. Owing to the size which umbilical herniæ frequently attain, it is not always easy to divide the constricting margin, and great care is needed to prevent the intestines being injured during the operation.

Ventral Herniæ. — This term is applied to those forms of hernia which protrude through the abdominal walls in situations not included in the inguinal and umbilical varieties. The most common variety is that which comes through the linea alba, usually above the umbilicus. They are small and mushroom-shaped, with narrow pedicles, and are commonly irreducible. In some cases these protrusions are masses of subperitoneal fat, emerging through foramina in the linea alba, growing after they protrude; so that these are not herniæ in the strict sense of the term. Ventral herniæ occasionally come through the linea semilunaris; others come through the triangular interval between the latissimus dorsi and posterior free border of the external oblique (*Petit's triangle*), and are termed *lumbar herniæ.*

There is, in fact, no part of the abdominal walls through which a hernia may not protrude.*

Dissection. — Expose the contents of the abdomen, by an incision from the ensiform cartilage to the os pubis a little to the left side of the linea alba, so as to preserve a ligament, *ligamentum teres*, which passes from the umbilicus to the liver, and also a cord, the *urachus*, which ascends in the middle line from the bladder to the umbilicus ; then make another incision transversely on a level with the umbilicus, and turn the flaps outwards.

Urachus. — Behind the linea alba, the peritoneum is raised into a fold by a fibrous cord, passing from the bladder to the umbilicus ; this is the *urachus*, which in fœtal life is a tube connecting the bladder with the allantois. On either side of the urachus are two other folds, enclosing cords which ascend obliquely towards the umbilicus : these are the impervious remains of the *hypogastric arteries*.

On opening the cavity of the peritoneum, there are seen, in connection with the fibrous cords just mentioned, two fossæ in the neighborhood of Poupart's ligament — one on the inner side, the other on the outer side of the obliterated hypogastric artery. The depth of these fossæ depends upon the tension of this cord ; so that, while sometimes they are scarcely visible, at others they are deep and well-marked. They are of importance, since they correspond with the internal and external abdominal rings ; hence, the greater depth of one or other hollow may determine the locality of the protrusion of a hernia. Occasionally the deep epigastric artery lies nearer the middle line than it normally does, so that we may have three pouches instead of two, through either of which a hernia may emerge.

The abdominal cavity is seen to be composed of two divisions — an upper or abdomen proper, and a lower or the pelvis. It is the upper division that we are about to describe.

Take now a survey of the viscera before they are disturbed from their relative positions.

What is Seen on Opening the Abdomen. — In the right hypochondrium, the right lobe of the liver is seen projecting more or less below the cartilages of the ribs, and the fundus of

* It should always be borne in mind, that, when possible in all large herniæ, especially abdominal, the patient should be kept in dorsal decubitus for at least one week before operative procedures are instituted as this will decrease the shock of the operation by depriving the protrusion of its blood, and enabling it to accommodate itself to the normal position. — A. H.

the gall-bladder below the edge of the liver, near the end of the ninth costal cartilage. In the left hypochondrium is seen more or less of the stomach according to its distention. Across the umbilical region extends a broad fold of the peritoneum containing fat, the great omentum, which descends from the lower curvature of the stomach, forming a curtain over the convolutions of the small intestine. The breadth of this fold varies; sometimes being so shrunk and crumpled as to be scarcely visible. The lower part of the abdomen and part of the pelvis are occupied by the small intestine. The urinary bladder is not apparent, unless distended sufficiently to rise out of the pelvis. In the right iliac fossa is the caput coli, the commencement of the large intestine; but the ascending part of the large intestine in the right lumbar region, and the descending part of it in the left, are not visible unless distended: they lie contracted at the back of the abdomen. Such are the viscera usually seen on opening the abdomen; but a certain latitude is to be allowed, as sometimes more of one organ is seen and less of another, according as this or that is distended or hypertrophied. Much also depends upon the amount of pressure which the ribs have undergone during life.

Particular Position of each Viscus. The Stomach.—The position of each viscus should now be examined separately, and first that of the stomach.

The *stomach* is irregularly conical in shape. It is placed obliquely, the smaller or pyloric end being the lower; its great end is situated in the left hypochondrium; its narrow or pyloric end extends obliquely across the epigastrium into the right hypochondrium, where it is overlapped by the liver.

The left or cardiac end is situated behind the ribs, and in contact with the concavity of the spleen, to which it is connected by a fold of peritoneum. In front it has the abdominal wall, above it has the liver and the diaphragm, and below it is the transverse colon; the right or pyloric end extends to the gall-bladder, and is in contact with the under aspect of the liver, where it is continuous with the duodenum; posteriorly, it rests on the pancreas, the aorta, and the two crura of the diaphragm. The stomach is connected with other viscera by the following peritoneal folds: (1) the great omentum, attached to its lower convex border, forms a curtain of fat, more or less thick, in front of the transverse colon and small intestines; (2) the gastro-hepatic or lesser omentum, which connects the lesser curve

of the stomach with the transverse fissure of the liver; and (3) the gastro-splenic omentum, which connects the cardiac end of the stomach with the hilum of the spleen. The relative position and size of the stomach vary according to the amount of distention: when much distended, the anterior surface, owing to the greater mobility of the great curve and the pyloric end of the stomach, is turned upwards, and the lower border forwards.*

Duodenum. — The first part of the intestinal canal is termed *intestinum duodenum*, because it is about the breadth of twelve fingers. Commencing at the pyloric end of the stomach, the duodenum ascends as high as the neck of the gall-bladder; then turning downwards it passes in front of the right kidney; lastly, making another bend, it crosses the spine obliquely towards the left side of the second lumbar vertebra. Here the intestinum jejunum begins, and this part of the canal may be seen by raising the transverse colon. Thus the duodenum describes a kind of horse-shoe curve, of which the concavity is towards the left, and embraces the large end or head of the pancreas. For convenience of description the duodenum is divided into an ascending, a descending, and a transverse portion. The first is completely surrounded by a peritoneal covering; the second and third are only covered by peritoneum in front, and are fixed to the back of the abdomen. The relative anatomy of the duodenum will be more fully seen hereafter.

Jejunum and Ileum. — Pursuing its course from the left side of the second lumbar vertebra, the intestinal canal forms a number of convolutions, occupying the lower regions of the abdomen, and which are loosely connected to the spine by a broad peritoneal fold termed the *mesentery*. Of these convolutions, the upper two-fifths constitute the *intestinum jejunum;* the lower three-fifths, the *intestinum ileum*. This is an arbitrary division. There is no definite limit; the character of the bowel gradually changes — that is, it becomes less vascular, has fewer folds of the lining membrane, and its coats are therefore less substantial to the feel.

Commencement of Large Intestine. — In the right iliac fossa, the small intestine opens into the left side of the cæcum, which is easily recognized by its sacculated appearance; here

* Lesshaft states that the position of the stomach is *vertical*, and that when distended it does not alter its position, but that it is affected equally in all directions. (*Lancet*, March 11, 1882.) This opinion is not, however, generally entertained by anatomists.

the large intestine begins, and it is guarded by the ileo-cæcal valve (*Bauhin*) (Fig. 164). Immediately below the junction the large intestine is expanded into a blind pouch, about two and a half inches (*6.3 cm.*) in length and breadth, called the *cæcum* or *caput coli.** Into the back part of this pouch opens a little tube, closed at the other end, called the *appendix vermiformis.* This tube varies from three to six (*7.5 to 11 cm.*) inches in length,† is about as thick as a large earthworm, and is either coiled up behind the cæcum, ‡ or is below it, having a separate mesentery attached to the abdominal wall posteriorly, which allows the apex to be loose in the abdomen. It is hollow, and its opening into the cæcum is usually guarded by a valve of mucus membrane.

The large intestine is about four and a half to five feet (*136.8 to 152.3 cm.*) in length, and in its course it describes an arch which encircles the convolutions of the small intestines. It is largest at its commencement, and lessens in size until at the upper part of the rectum it becomes narrowest; below this it again forms a dilatation, the *ampulla,* just above its termination at the anus. It is successively divided into cæcum, ascending, transverse, and descending colon, sigmoid flexure, and rectum. The commencement of the large intestine is generally confined by the peritoneum to the iliac fossa, in which it lies, being separated from the iliacus muscle by the iliac fascia and by more or less connective tissue and fat.§ Tracing the large intestine from this point, it is continued as the *ascending colon.* We find it somewhat smaller than the cæcum, and it ascends through the right lumbar region in front of the right kidney as high as the under surface of the liver, where it abruptly makes a bend to the left side — the *hepatic flexure* of the colon; it then crosses the umbilical region transversely from right to left, and is known as the *transverse colon.* Reaching the left hypochondriac

* Out of seventy-four cases observed by the editor the colon occupied the iliac ventre in fifty-six; occupying the ventre and extending into the true pelvis in twelve; attached to abdominal viscera in two. (*Amer. Jour. Med. Soc.* Aug. 1893.) — A. H.

† Average length of vermiform appendix observed in 73 cases was *8.97 cm.*, with a maximum of *17 cm.*, and a minimum of *2.5 cm.* — A. H.

‡ Out of 71 cases the appendix was observed in the inner and posterior aspect of the colon in 56; on the inner in 8; on the posterior in 6; and on the inferior in 2. — A. H.

§ But this is not invariably so. The bowel is, in some subjects, connected to the fossa by a fold of peritoneum or a *meso-cæcum.* I have seen this fold sufficiently loose to allow the caput coli to travel over to the left iliac fossa.

region, it makes a sharp bend downwards beneath the lower border of the spleen, forming the *splenic flexure* of the colon ; * thence it descends in front of the left kidney,† through the left lumbar region into the left iliac, as the *descending colon.* In the iliac fossa the intestine, as the *sigmoid flexure,* becomes narrow and makes a curve like the letter S.‡ Lastly, the bowel enters the pelvis on the left side of the sacrum, and here takes the name of *rectum.* This term, so far as concerns the human subject, is misapplied ; the canal runs anything but a straight course through the pelvis, since it curves to adapt itself to the sacrum.

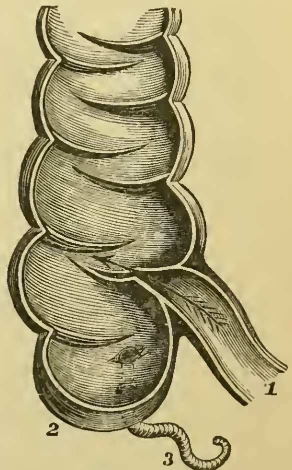


Fig. 164. — Section through the Junction of the Large and Small Intestine to show the Ileo-Cæcal Valve and Appendix Vermiformis.

1. Ileum. 2. Cæcum or caput coli. 3. Appendix Vermiformis.

Looking at the entire course of the colon, observe that it forms an arch, of which the concavity embraces the convolutions of the small intestines.

Let us now see to what extent the small and the large intestines are invested with a peritoneal coat. The *small intestines,* with the exception of the duodenum, which cannot at present be examined, we shall find are completely surrounded by peritoneum, except at their mesenteric border, along which the vessels pass to the bowel ; the *cæcum* is covered, as a rule, only in front and on its sides, the posterior surface being connected to the iliac fascia by connective tissue ; the *ascending colon* is also only covered on the front aspect and sides, the posterior surface being loosely connected by areolar tissue to the quadratus lumborum and right kidney ; the *transverse colon* is almost entirely surrounded by peritoneum, which is reflected hori-

* This transverse part of the colon, in some instances, makes a coil behind the stomach to the diaphragm; such a state of things, when the bowel happens to be distended, is apt to give rise to symptoms of diseased heart. See some observations in point by Dr. Copland, in *Lond. Med. Gaz.* 1847, vol. v. p. 660.

† The contiguity of the ascending and descending colon to the right and left kidney respectively, explains the occasional bursting of renal abscesses into the intestinal canal.

‡ It will be noticed that this fold is more *omega*-shaped, Ω, as first pointed out by Treves. — A. H.

zontally backwards as a broad double layer — the transverse meso-colon — to the spine; the *descending colon*, smaller than the transverse colon, and more deeply situated than the ascending colon, is only invested with peritoneum on its anterior and inner surfaces; the *sigmoid flexure* is completely invested with peritoneum, which connects this part of the bowels with a loose fold to the left iliac fossa; the *rectum* is completely surrounded by peritoneum in its upper half, and is connected to the front of the sacrum by a fold, the *meso-rectum;* the lower half of the rectum, for the first three inches (*7.5 cm.*), is only covered in front with peritoneum; the last inch and a half (*3.8 cm.*) has no peritoneal investment at all.*

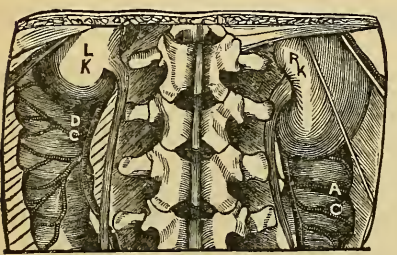


Fig. 165. — Relative Position of the Kidneys and the Large Intestine seen from Behind.

L. K. Left Kidney. R. K. Right Kidney, crossed obliquely by the last thoracic artery and nerve. A. C. Ascending colon. D. C. Descending colon.

Relations of the Large Intestine. — At present we have only traced the course of the large intestine through the different abdominal regions, but now we are able to see the relations of the various portions of the bowel.

The *cæcum* rests in the right iliac fossa, separated from the iliacus by the iliac fascia and connective tissue; in front it has the anterior abdominal wall.

The *ascending colon* has behind it the quadratus lumborum and right kidney; in front, it has the abdominal wall and small intestines; above, it is in contact with the under aspect of the liver to the right of the gall-bladder.

The *transverse colon* is concave posteriorly, and has above, the liver, gall-bladder, the stomach, and the lower border of the spleen; behind, it has the transverse meso-colon and the third part of the duodenum; in front, it is in contact with the abdominal wall and great omentum; below, with the small intestines.

The *descending colon*, deeper situated than the ascending colon, lies behind, in contact with the left crus of the diaphragm,

* It should be recollected, that the ascending and descending colon are not infrequently completely invested by peritoneum, and therefore, virtually speaking, have a mesentery. This occasional occurrence is important when the operation of right or left lumbar colotomy has to be performed.

the left kidney and quadratus lumborum; in front, with the small intestines, and on its left side, with the abdominal wall.

The *sigmoid flexure* is in relation behind with the iliac fossa, the left spermatic artery and ureter, the left common iliac vessels; in front, with the small intestines and abdominal wall.

The relations of the *rectum* cannot at present be satisfactorily made out; the description of them has been deferred till the dissection of the side view of the pelvic viscera.

Length of the Alimentary Canal. — The small intestine, including the duodenum, varies from sixteen to twenty-four feet in length, and the large intestine from four and a half to five feet (*136.8 to 152.3 cm.*); these measurements are subject to some variation according to the height of the subject.

Situation of the Liver. — The liver occupies the whole of the right hypochondrium, and extends over the epigastric region, more or less, into the left. Unless the individual be very corpulent we can ascertain during life the extent to which the liver projects below the costal cartilages, and the general dimensions of the organ may be tolerably well told by percussion. Its *anterior border* is sharp and thin, and presents in the epigastric region a deep notch for the round ligament, and generally projects a little way below the ribs; its *posterior border* is broad and connected to the diaphragm by the coronary ligament; it is in relation behind with the inferior vena cava, the aorta, and the crura of the diaphragm. Its *upper convex surface* ascends as high as the fifth intercostal space, is accurately adapted to the arch of the diaphragm, and is divided into two unequal parts by the falciform or suspensory ligament; its *under surface* overlies part of the stomach, and of the duodenum, the right kidney and supra-renal capsule, and the hepatic flexure of the colon. Its *right border* is thick; its *left* is thin and sharp. To the diaphragm the liver is connected by folds of peritoneum, called *ligaments*. One of these, nearly vertical in direction, and called the *suspensory*, or, from its shape, the *falciform* ligament, is situated a little to the right of the mesial line. The lower and free edge of it contains the impervious remains of the umbilical vein, called the *round* ligament. The suspensory ligament, traced backwards, leads to another broad fold extending horizontally from the diaphragm to the posterior border of the liver; this constitutes the *lateral* ligament, right or left, according as we trace it on one or the other side of the falciform ligament.

The junction of the lateral and falciform ligaments is described by some authors as the *coronary* ligament.

Situation of the Gall-bladder. — The gall-bladder is the reservoir for the bile, and is closely confined by the peritoneum in a slight depression on the under surface of the right lobe of the liver, to which it is connected by areolar tissue; occasionally the gall-bladder is completely surrounded by peritoneum. It is pyriform in shape, and its broad end or fundus, covered with peritoneum, projects beneath the anterior border of the liver opposite the ninth costal cartilage. It measures three to four inches (*7.5 to 10 cm.*) in length, is an inch and a half (*3.8 cm.*) broad, and contains from eight to twelve drachms (*32 to 48 c. c.*). The neck is inclined upwards and towards the left, and is firmly connected to the liver by areolar tissue. The gall-bladder is in relation *above* with the liver and small blood-vessels; *below*, with the transverse colon and with the first portion of the duodenum; its *neck* is curved upon itself like the letter S, and bending downwards terminates in the cystic duct. It sometimes happens that the gall-bladder, in consequence of some obstruction to its duct, becomes unusually distended, and occasions a swelling below the margin of the ribs, which might be mistaken for a hepatic abscess. The close proximity of the gall-bladder to the duodenum and the transverse colon explains the occasional evacuation of gall-stones by ulceration into the intestinal canal.

Situation of the Spleen. — The spleen is the dark, purple-gray, flattened organ deeply situated in the left hypochondrium, between the stomach and the ninth, tenth, and eleventh ribs. It is placed nearly vertically; its outer surface is smooth and convex, to correspond with the diaphragm and ribs; its inner surface, where its great vessels enter, is concave, and connected to the great end of the stomach by a broad peritoneal fold, called the *gastro-splenic omentum*. Its *external surface* is in relation with the diaphragm which separates the organ from the ninth, tenth, and eleventh ribs; its *internal surface* is concave, and presents a vertical fissure — the *hilum* — situated nearer the posterior than the anterior border; it is at this fissure that the two layers of peritoneum are reflected from the stomach to the spleen, and the splenic vessels enter and emerge; it is in relation with the cardiac end of the stomach, the tail of the pancreas, the left supra-renal capsule, and the left crus of the diaphragm; the *upper border* is rounded, and is connected to the diaphragm by a fold of peritoneum — the *suspensory ligament;* the *lower border* is in contact with the splenic flexure of the colon; the *posterior*

border is thick, and is connected with the left kidney by areolar tissue; the *anterior margin* * usually presents a more or less deep notch. Its hilum is connected with the cardiac end of the stomach by a fold of peritoneum — the *gastro-splenic omentum;* and with the under surface of the diaphragm by a small peritoneal fold — the *suspensory ligament.*†

Situation of the Pancreas. — This is the large salivary gland of the abdomen. It is placed transversely across the back of the abdomen, in front of the spine, about the level of the first lumbar vertebra. It is about seven inches (*17.5 cm.*) in length, and an inch and a half (*3.8 cm.*) in breadth. Its *right end* or *head* is contained within the curve of the duodenum; its *left end*, or *tail*, extends as far as the spleen. The further connections and relations of the pancreas cannot at this stage of the dissection be satisfactorily seen.

Situation of the Kidneys. — The kidneys are two large excretory glands, situated at the back of the abdomen *post peritoneal* in each lumbar region, nearly opposite the two last thoracic and the two upper lumbar vertebræ — the right, owing to the size of the liver, being a little lower than the left. They lie imbedded in fat, which maintains them in their proper position. *Behind*, they rest on the crus of the diaphragm, on the quadratus lumborum and psoas, separated by the aponeurosis of the transversalis; in *front*, the right kidney is in relation with the peritoneum, the right lobe of the liver, the second part of the duodenum, and the ascending colon: the left kidney is in contact with the peritoneum, the cardiac end of the stomach, the spleen, the end of the pancreas, and the descending colon; *externally*, it is convex, and in contact with the abdominal parietes; *internally*, it is concave, and presents a deep hollow — the *hilum*, from which pass the ureter and large vessels; *above*, it is in relation with the supra-renal capsule; *below*, it extends nearly as low as the crest of the ilium.

Situation of the Supra-renal Capsules. — These are two ductless glands, situated at the top of the kidneys and behind the peritoneum. The right one is triangular; the left, oval and almond-shaped. The right supra-renal capsule is in relation *in front* with the under aspect of the liver; the left, with

* This margin is parallel to a line drawn from the left sterno-clavicular articulation to the ventral extremity of last rib. — A. H.

† We find occasionally in the gastro-splenic omentum one or more small spleens in addition to the large one.

the pancreas and spleen; *behind*, it rests on the crus of the diaphragm; the *upper border* is convex and thin; the *lower border* is concave, and rests on the kidney; the *inner border* is in relation with the semilunar ganglion and splanchnic nerves, and with the vena cava on the right side, and with the aorta on the left side. The anterior surface is slightly indented, from which the supra-renal vein passes out to join on the right side the inferior vena cava, and on the left side the left renal vein.

Peritoneum. — A certain range of motion being necessary to the abdominal viscera, they are provided with a serous membrane, called the *peritoneum*. This membrane, like other serous membranes, is a closed sac, one part of which lines the containing cavity, the other is reflected over the contained viscera. These are respectively termed the *parietal* and the *visceral* layers. In the female, however, it is not, strictly speaking, a closed sac, since it communicates with the cavity of the uterus through the Fallopian tubes. The internal surface of the peritoneum is smooth and polished, and lined by squamous endothelium; the external surface — the *sub-peritoneal tissue* — is composed of areolar tissue, which connects the internal layer to the invested viscus or abdominal parietes. There is nothing between the parietal and the visceral layers — in other words, inside the sac — but just sufficient moisture to lubricate its smooth and polished surface. The viscera are all, more or less, outside the sac; some lie altogether behind it, as the pancreas, kidneys, and supra-renal capsules; others, as the lower parts of the duodenum, cæcum, ascending and descending colon, are only partially covered by it; while others, as the stomach, liver, jejunum, ileum, and some parts of the large intestine, are completely invested by it; these latter push the visceral layer before them, and so give rise to membranous folds; the larger the fold, the freer is the mobility of the viscus which occasions it.

To understand the peritoneum some knowledge of its formation and growth is necessary. This primitive serous membrane has two layers, a *parietal* lining the inside of the somatopleure, and a *visceral*, the mesentery, covering the outside of the splanchnopleure; consequently in a plane section these layers are continuous. It follows, therefore, that as the splanchnopleure becomes complex by its increase in length and outgrowths, so the visceral layer of the serous membrane must be complicated also.

The primitive alimentary canal is held to the vertebral column

by a dorsal mesentery and a ventral mesentery above the umbilicus. The liver developed in this ventral fold is an offshoot from the alimentary tube. This fold forms the suspensory, lateral and coronary ligaments and the gastro-hepatic omentum. By the rotation of the stomach on its vertical axis and the turning of the large bowel over the small intestines, — *i.e.*, the change of the caput-coli from left to right, and the small bowel to a place encircled by the large, — the great curve of the

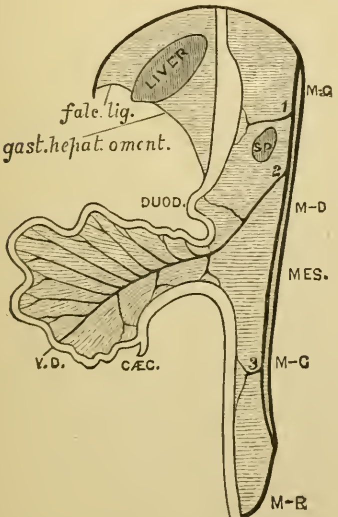


Fig. 166. — Diagram of the Primitive Alimentary Canal (Morris).

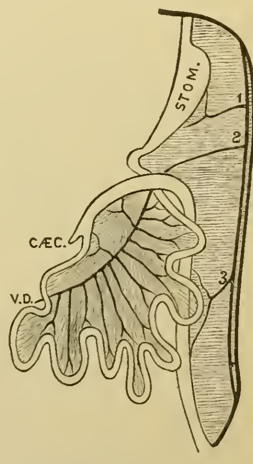


Fig. 167. — Diagram to show the Rotation of the Intestinal Canal (Morris).

stomach becomes ventrally placed, and the traction of the growth of the peritoneum deprives the duodenum of its covering on its dorsal and lateral walls, thereby forming the mesenteries of the small and large bowels. The formation of the omentum is accomplished by the stretching of the dorsal fold of mesogastium in the act of rotation.

The term omemtum is applied to peritoneal connections passing to other visceral from the stomach, *i.e.*, gastro-hepatic, gastro-splenic. Mesentery is aplied to peritoneal connections passing from the intestinal tube, small or large intestines, to the abdominal wall; *i.e.*, mesentery proper for the small bowel, meso-colon, etc.

Ligament is applied to peritoneal folds connecting viscera, not directly connected with the intestinal tube, *i.e.*, of the liver, spleen, bladder, and uterus. (A. H.)

Course of the Peritoneum. — Now trace the peritoneum as a continuous membrane. Since the peritoneum is a perfect sac, it matters not where we begin; we must come back to the starting-point.

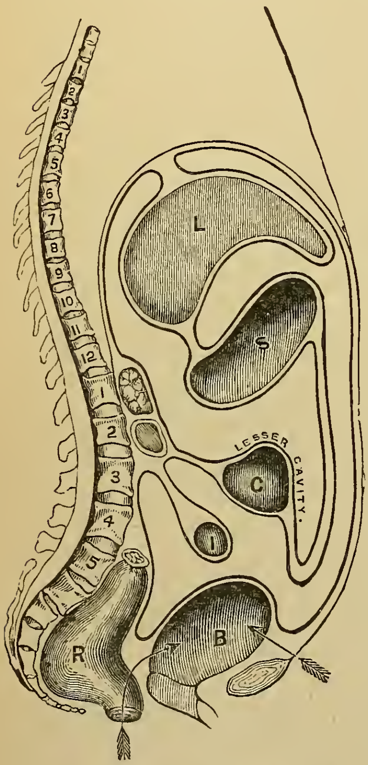


Fig. 168. — Diagram of the Peritoneum.

If a longitudinal section be made through the viscera in the middle of the body, one can trace the peritoneum thus — beginning at the diaphragm, and taking, for brevity's sake, two layers at a time (Fig. 168).

From the diaphragm two layers of peritoneum proceed to the liver, forming its *lateral ligaments;* they separate to enclose the liver, meet again on its under aspect, and pass on under the name of the *gastro-hepatic omentum,* to the small curve of the stomach. Separating here, they embrace the stomach, and, meeting again at its greater curve, pass down like a curtain over the small intestine to form the *great omentum.* At the lower margin of the great omentum they are reflected upwards (so that the great omentum consists of four layers) to the front of the transverse colon, which they enclose, and, after joining again at the back of the colon, proceed to the spine, forming the *transverse meso-colon.* At this situation the two layers diverge, the upper one ascends in front of the pancreas, and the crura of the diaphragm to its under surface, at which point we started.*

* In fœtal life, the ascending layers of the great omentum may be traced back to the spine near the pancreas; and here the layers diverge from each other. The upper layer ascends in front of the pancreas to the diaphragm; the lower layer

The peritoneum passes from the under surface of the right lobe of the liver to the kidney, forming a slight fold — the *hepato-renal fold;* on the left side, where the peritoneum extends from the diaphragm to the cardiac end of the stomach, it passes as a slight duplicature, forming the *gastro-phrenic ligament;* an extension of this is seen passing as a distinct fold — the *costo-colic ligament* — from the diaphragm to the splenic flexure of the colon.

The lower layer is reflected from the spine over the small intestine, back again to the spine, to form the *mesentery.* From the root of the mesentery it descends into the pelvis, and invests the upper two-thirds of the rectum. From the rectum, in the male, it is reflected to the posterior part of the bladder, forming the *recto-vesical pouch,* and thence to the wall of the abdomen, along which it can be traced up to the diaphragm. In the female, it is reflected from the rectum onto the posterior wall of the vagina half an inch (*13 mm.*) from the uterine extremity, constituting the recto-vaginal pouch (*Douglas's pouch*), and thence over all the back, but only about half-way down the front of the uterus, to the posterior wall of the bladder; after which its reflections are the same as in the male.*

Such is the course of the peritoneum as seen in a longitudinal section, but there are lateral reflections which cannot be seen except in a transverse section: thus, from the great end of the stomach, two layers proceed to the spleen, forming the *gastro-splenic omentum;* from the transverse meso-colon, it is reflected on either side over the ascending and descending colon.

The structures *completely invested* with peritoneum are, the stomach, liver, first part of the duodenum, the jejunum and ileum, the transverse colon, sigmoid flexure, upper part of rectum, spleen, uterus, and ovaries.

The following parts of the alimentary canal are only *partially covered* by peritoneum: namely, the descending and transverse portions of the duodenum, the cæcum, the ascending and descending colon (with exceptional cases), the middle part of the rectum, the upper part of the vagina, and the hinder wall of the bladder.

proceeds over the arch of the colon, and then back to the spine, thus forming the transverse meso-colon. Its reflections afterwards are the same as in the adult. As the fœtus grows, the great omentum becomes adherent to the arch of the colon.

* For a detailed description of the development of the great omentum and the transverse meso-colon, see a paper by C. B. Lockwood, *Journal of Anatomy and Physiology*, vol. xviii.

The viscera *uncovered* by peritoneum are, the lower part of the rectum, the anterior and the lower part of the posterior wall of the vagina, the anterior and part of the posterior wall of the bladder.

Anatomists speak of the *lesser cavity of the peritoneum*, as distinguished from the greater. This lesser cavity, or *cavity of the great omentum*, is situated behind the stomach and the descending layers of the great omentum. If air be blown through the foramen of Winslow (which is the constricted communication between the greater and lesser cavities of the peritoneum), the lesser cavity becomes distended. It is bounded *in front* by the lesser omentum, the stomach, and the descending layers of the great omentum; *behind*, by the ascending layers of the great omentum, the colon, the upper layer of the transverse meso-colon and its ascending layer; *above*, by the liver; *below*, by the turn of the great omentum.

Foramen of Winslow. — This foramen is the narrow circular opening between the greater and lesser cavities of the peritoneum, through which the two cavities communicate. It is situated behind the right edge of the gastro-hepatic or lesser omentum. By passing your finger into it, you will find the foramen bounded *above*, by the lobulus Spigelii or caudatus of the liver; *below*, by the commencement of the duodenum and by the curving forwards of the hepatic artery; *in front*, by the gastro-hepatic omentum, enclosing the hepatic artery and duct and the vena portæ; and *behind*, by the vena cava inferior.

Mesentery. — This is the fold which suspends the small intestine from the back of the abdomen. To see it, raise the great omentum and the transverse arch of the colon. Its attached part or root is about six inches (*15 cm.*) in length, and extends from the left side of the second lumbar vertebra obliquely across the spine to the right sacro-iliac symphysis. The loose part of the mesentery is very broad, and curves like a ruffle, enclosing the small intestine from the beginning of the jejunum to the end of the ileum. Its shape resembles an open fan, and its length from the vertebral column to its attachment to the intestine is about four inches (*10 cm.*). Above, it is connected with the under surface of the transverse meso-colon; below, with that part of the peritoneum which lines the inner part of the cæcum and ascending colon. We must trace between its two layers the mesenteric vessels, nerves, glands, and lymphatics.

Transverse Meso-colon. — This broad fold connects the transverse colon to the back of the abdomen, and between its layers the vessels pass to and from this portion of the larger gut. It forms an imperfect partition dividing the abdomen into an upper compartment, containing the stomach, liver, and spleen ; and a lower, containing the convolutions of the small intestines.

Ascending and Descending Meso-colon. — As regards the cæcum, and the ascending and descending portions of the colon, they are, as a general rule, bound down by the peritoneum in their respective situations. The peritoneum covers only two-thirds or thereabouts of their anterior surface ; their posterior surface is connected by loose cellular tissue to the back of the abdomen. The colon, ascending or descending, can therefore be opened in the lumbar region, below the kidney, without injury to the peritoneum : a fact upon which is founded the operation of colotomy for the relief of stricture of the rectum. In some cases, the ascending and descending colon (more commonly the latter) are completely surrounded by peritoneum and connected to the lumbar regions, respectively, by a right and a left *lumbar meso-colon.*

Sigmoid Meso-colon. — The sigmoid flexure is, as a rule, completely invested by peritoneum, which passes as a thin fold to the iliac fossa, allowing a considerable amount of movement of this part of the intestine.*

Meso-rectum. — The upper third of the rectum is also surrounded by peritoneum, which passes to the sacrum and thus retains it in position. The hæmorrhoidal vessels pass between its layers.

Great Omentum. — This broad peritoneal fold, known also as the *gastro-colic omentum,* is composed of four layers, and proceeds as a double layer from the lower border of the stomach, as far as the pelvis, where these two layers ascend to enclose the transverse colon. It lies like a curtain over the convolutions of the small intestines, and we find it in some bodies extending low into the pelvis ; in others, small and crumpled up, usually in the left hypochondrium. Its thickness varies considerably : in thin subjects it is often translucent ; in corpulent persons, on the other hand, it is loaded with fat, and contributes in great measure to the size of the abdomen.

* The length of this mesentery enables the now more preferable inguinal artificial anus to be made in disease of the rectum. — A. H.

Gastro-hepatic or Lesser Omentum. — This double fold passes from the transverse fissure on the under surface of the liver to the upper curve of the stomach. It is composed of two layers, and between them are the portal vein and hepatic artery, with the nerves going to the liver, and the hepatic duct and lymphatics coming from it. The right border of this fold is free, and forms the anterior rounded margin of a constriction, called the *foramen of Winslow,* which leads into the lesser cavity of the peritoneum ; its left border passes on to the œsophagus. In this fold the common bile duct lies to the right, the hepatic artery to the left, and the vena portæ behind and between them. If now the finger be introduced behind the right border, it passes through the foramen of Winslow into the lesser cavity of the peritoneum.

Gastro-splenic Omentum. — This fold proceeds from the great end of the stomach to the spleen, and is continuous below with the great omentum. It contains between its layers the branches, *vasa brevia,* which proceed from the splenic artery to the great end of the stomach.

Ligaments. — The reflections of the peritoneum from the abdominal walls to the liver, the spleen, the bladder, and uterus, and constituting their *ligaments,* have been, or will be, described with the respective viscera.

Before removing any portion of the anterior fold of the peritoneum it is necessary to call attention to several pouches formed in its development, which may become the seat of intra-abdominal herniæ. They are named from their position (1) fossa duodeno-jejunalis; (2) the fossa subcæcalis; and (3) the fossa intersigmoidea.

1. The *fossa duodeno-jejunalis* may be seen by elevating the stomach with the omentum attached to its greater curvature, and the transverse colon, and turning the coils of the small intestines to the right. The fossa is situated to the left of the terminal portion of the duodenum, passing to the abdominal wall. Its entrance is bounded by a free semilunar fold (*duodeno-jejunal*), forming a pouch in front and to the left of the vertebræ. According to Treves this fold is found in fifty per cent of all cases. This fossa may become distended and a large portion of the jejunum may be lodged therein. 2. The *fossa subcæcalis* may be seen by drawing the cæcum forwards and to the right. It is formed by two folds of peritoneum, the superior from the lateral and dorsal wall of the cæcum above the

ilio-cæcal valve, and the inferior from the lowest portion of the ilio-cæcal junction terminating on the ilium. The superior fold ending on the iliac fossa. 3. The *fossa intersigmoidea* may be seen by elevating the sigmoid loop of the large bowel, and according to Henle, the orifice lies over the interval between the psoas and iliacus muscles. This is a very rare occurrence, but may explain the meso-colic hernia of Cooper, which depends upon the prominence of the inferior mesenteric artery in this position of the peritoneum. (A. H.)

Branches of the Abdominal Aorta. — Our next object should be the examination of the arteries which supply the viscera. The *abdominal aorta* enters the abdomen between the pillars of the diaphragm in front of the last thoracic vertebra, and then, descending a little to the left of the spine, divides on the body of the fourth lumbar vertebra, a little to the left of the middle line into the two common iliac arteries. The relations of the aorta cannot at present be sufficiently made out, so that this will be described later on. In its course it gives off its branches in the following order (Fig. 169): —

1. The *phrenic*, for the supply of the diaphragm.

2. The *cœliac axis*, a short, thick trunk, which immediately subdivides into three branches for the supply of the stomach, the liver, and the spleen.

3. The *superior mesenteric*, for the supply of all the small intestines and the upper half of the large.

4, 5. The *supra-renal* and the *renal* arteries.

6. The *spermatic*, for the testicles; the *ovarian*, for the ovaries.

7. The *inferior mesenteric*, for the supply of the lower half of the large intestine.

8. The *lumbar*, four branches analogous to the intercostals, for the supply of the back part of the abdomen.

9. The *arteria sacra media*, which is given off at the bifurcation of the aorta, supplies the fifth lumbar artery, and, running down in front of the sacrum, supplies the rectum and other structures.

By some anatomists the branches are arranged in two classes — those destined to supply the viscera, and those to supply the abdominal parietes: the former are the cœliac axis, supra-renal, renal, spermatic, superior and inferior mesenteric arteries; the latter are the phrenic, the lumbar, and sacra media arteries.

Dissection. — These branches are to be traced throughout in the following order. Take the cœliac axis first. To dissect this artery and its branches, the liver must be well raised and the stomach drawn down, as in Fig. 170, and the anterior layer of peritoneum removed from the gastro-hepatic omentum. A close network of very tough tissue surrounds the visceral branches of the aorta. This tissue consists almost entirely of plexuses of nerves, derived from the sympathetic system, each plexus taking the name of the artery which it surrounds. Of these plexuses, the largest surrounds the cœliac axis like a ring. This is the solar plexus, and is formed by the junction of the two semi-lunar ganglia (Fig. 75, p. 205). From this, as from a root, other secondary plexuses branch off, and surround the following arteries — the phrenic, coronary, hepatic, splenic, superior mesenteric, inferior mesenteric, and renal, the plexuses receiving the names of the arteries around which they twine. It requires a lean subject and much patience to trace them.

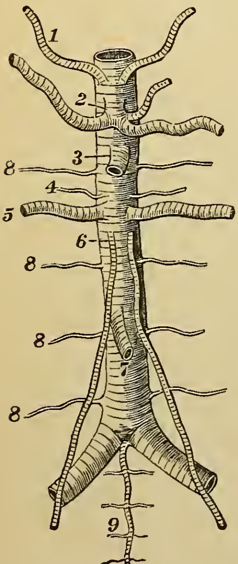


Fig. 169 — Branches of the Abdominal Aorta.
1. Phrenic. 2. Cœliac axis. 3. Superior mesenteric. 4. Supra-renal. 5. Renal. 6. Spermatic. 7. Inferior mesenteric. 8. Lumbar. 9. Sacra media.

Cœliac Axis and its Branches.— The *cœliac axis* arises from the front of the aorta, between the pillars of the diaphragm, immediately above the upper border of the pancreas, to the left of the lobulus Spigelii, to the right of the cardiac end of the stomach, and having the semilunar ganglia on each side. It is a short, thick trunk which runs between the two layers of the lesser omentum, and, after a course of about half an inch (*13mm.*), divides into three branches, the hepatic running to the right, the splenic to the left, and the coronaria ventriculi upwards and to the left side.

The following is the plan of the cœliac axis and its branches:

Cœliac Axis.	Coronaria ventriculi . .	œsophageal.	
		gastric.	
	Hepatic . .	pyloric.	
		gastro-duodenalis.	gastro-epiploica dextra.
			pancreatico-duodenalis superior.
		cystic.	
	Splenic . . .	pancreatic branches.	
		gastro-epiploica sinistra.	
		vasa brevia to stomach.	

Coronaria Ventriculi. — The *coronaria ventriculi*, the smallest of the three, ascends a little to the left towards the œsophageal end of the stomach, where it gives off *œsophageal* branches, which anastomose with the œsophageal branches of the thoracic aorta; and others to the cardiac end of the stomach, which inosculate with the vasa brevia of the splenic artery. It then runs from left to right, along the lesser curvature of the stomach

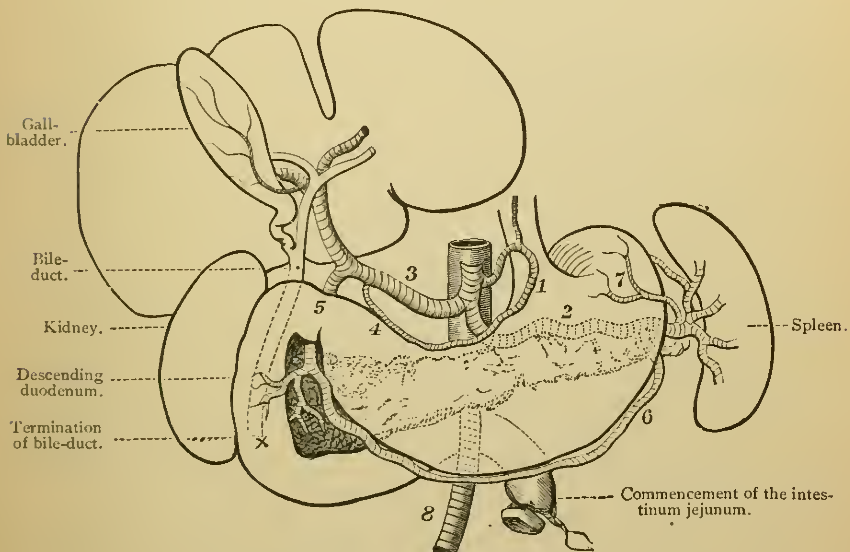


FIG. 170. — DIAGRAM OF THE BRANCHES OF THE CŒLIAC AXIS.
(Pancreas in dotted outline behind the stomach.)
6. Coronaria ventriculi. 2. Splenic a. 3. Hepatic a. 4. Pyloric a. 5. Gastro-duodenalis. 6. Gastro-epiploica sinistra. 7. Vasa brevia. 8. Superior mesenteric a.

towards the pylorus, supplying branches on both surfaces of the stomach, and finally anastomoses with the pyloric branch of the hepatic artery.

Hepatic Artery. — The *hepatic artery* ascends to the right between the layers of the lesser omentum to the transverse fissure of the liver, where it divides into two branches, right and left, for the supply of the respective lobes of the liver.

In its course to the liver, it lies to the left of the common bile-duct and in front of the portal vein: all three are contained in the right half of the lesser omentum. The hepatic gives off —

a. The *pyloric*, which descends to the upper border of the pylorus, and runs along the lesser curve of the stomach from right to left, inosculating with the coronaria ventriculi.

b. The *gastro-duodenalis* descends behind the ascending portion of the duodenum, divides, after a short course, into (*a*) the *gastro-epiploica dextra*, which runs along the greater curve of the stomach, between the layers of the great omentum, from right to left, and anastomoses with the gastro-epiploica sinistra from the splenic, supplying both surfaces of the stomach and the great omentum; and (*b*) the *pancreatico-duodenalis superior*, which runs down between the head of the pancreas and the descending portion of the duodenum, and anastomoses with the pancreatico-duodenalis inferior, a branch of the superior mesenteric, and with the pancreatic branches of the splenic.

c. The *cystic*, commonly a branch of the right hepatic, ascends along the neck of the gall-bladder, and divides into two branches, one of which ramifies on the under surface of the gall-bladder, the other passes between the liver and the upper surface of the gall-bladder.

Splenic Artery.—The *splenic*, the largest of the three, proceeds tortuously towards the left side, above its corresponding vein, along the upper border of the pancreas to the hilum of the spleen, which it enters by numerous branches.

It gives off: 1. Several small branches to the pancreas, *pancreaticæ parvæ:* one, rather larger than the rest, *pancreatica magna*, accompanies the pancreatic duct. These arteries anastomose with the pancreatico-duodenal branches of the hepatic and superior mesenteric arteries. 2. The *gastro-epiploica sinistra*, which runs to the right along the great curve of the stomach, between the layers of the great omentum, and inosculates with the gastro-epiploica dextra. 3. The *vasa brevia*, five to seven in number, which proceed between the layers of the *gastro-splenic* omentum, to the great end of the stomach, where they communicate with branches from the coronaria ventriculi, and the gastro-epiploica sinistra. 4. The *splenic* branches are five or six in number, and enter the fissure of the spleen.

Thus the stomach is supplied with blood by four channels, which by their inosculations form a main artery along its lesser curve, another along its greater; from these, numerous branches are furnished to both surfaces of the stomach. The artery of the greater curve also sends down numerous *omental* branches, which form a network between the layers of the great omentum.

The vein corresponding to the coronaria ventriculi artery, called the *coronary*, commences close to the pylorus, runs along the lesser curve of the stomach as far as the œsophagus, and then, descending to the right, between the two layers of the gastro-hepatic omentum, opens into the vena portæ.

The *splenic vein* returns the blood from the spleen by five or six branches which unite to form a single trunk. This runs along the upper border of the pancreas below the artery, and after receiving the branches corresponding to the branches of the artery and the inferior mesenteric vein, joins the superior mesenteric vein to form the vena portæ.

The *hepatic veins* do not run with the hepatic artery, but return the blood from the liver and terminate in the vena portæ.

Vena Portæ: its Peculiarities. — The veins which return the blood from the abdominal portion of the alimentary canal, the pancreas, and the spleen, do not empty themselves into the vena cava inferior, but all unite into one large vein, called the *vena portæ*, which ramifies throughout the liver, and secretes the bile. The trunk of the vena portæ itself is about three inches (*7.5 cm.*) long. Tracing it downwards, you find that it is formed behind the great end of the pancreas and in front of the inferior cava by the confluence of the splenic and superior mesenteric veins (Fig. 171). In its passage to the liver, the vena portæ is accompanied by the hepatic artery and the common bile-duct, lying behind and between them. At the transverse fissure of the liver it presents a slight enlargement, called the *sinus*, and then divides into two branches corresponding to the right and left lobes. The vein ramifies in the substance of the liver like an artery, and is surrounded, with the branches of the hepatic artery and duct, in a sheath of areolar hepatic tissue called *Glisson's capsule.* The vena portæ may, then, be compared to the stem of a tree, of which the roots arise in the digestive organs, and the branches spread out in the liver. After receiving the veins corresponding to the branches of the hepatic artery, the vena portæ returns its blood into the inferior vena cava through the venæ cavæ hepaticæ.

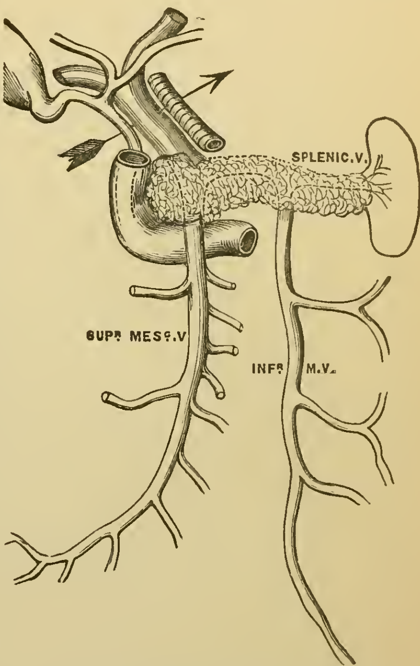


FIG. 171.—DIAGRAM OF THE VENA PORTÆ.
(The arrow is introduced behind the free border of the lesser omentum.)

The veins which empty themselves into the vena portæ have no valves. Therefore, if any obstruction arises in the venous

circulation through the liver, the roots of the portal vein are apt to become congested; this is a common cause of hæmorrhoids, diarrhœa, hæmorrhage from the bowels, and ascites.

Hepatic Duct. — The hepatic duct is formed by the junction of the right and left hepatic ducts, which issue from the transverse fissure. The hepatic duct descends nearly vertically for about an inch and a half (*3.8 cm.*), when it is joined at an acute angle by the cystic duct.

Cystic Duct. — The *cystic duct*, about an inch (*2.5 cm.*) in length, descends from the neck of the gall-bladder, towards the left in the gastro-hepatic omentum, lying to the right of the hepatic artery and in front of the vena portæ.

Ductus Communis Choledochus. — The hepatic and cystic ducts unite to form the *ductus communis choledochus*, or the common bile-duct; the duct thus formed passes downwards and to the left, between the two layers of the lesser omentum, close to its right border. It is about three inches (*7.5 cm.*) long, and if distended would be about the size of a crow-quill. It descends behind the first portion of the duodenum; in front of the vena portæ; to the right of the hepatic artery; to the left of the descending portion of the duodenum; and behind the head of the pancreas. Then turning towards the right, it gets behind the descending duodenum, and opens obliquely into the back part of the second portion, near the junction with the third. The duct runs through the coats of the bowel for nearly three-quarters of an inch (*18 mm.*), and sometimes before doing so unites with the pancreatic duct.

Dissection. — The great omentum, with the arch of the colon, must now be turned up over the chest, and the small intestines pushed towards the left side. Then, by removing the anterior layer of the peritoneum from the mesentery, we expose the mode in which the superior mesenteric artery ramifies so as to supply the small intestines. In making this dissection, the mesenteric glands immediately attract notice. They lie in great numbers between the layers of the mesentery, and vary considerably in size. The fine tubes, called lacteal vessels, which traverse the glands, are too thin and transparent to be seen under ordinary circumstances. But in cases where sudden death has taken place during digestion, they are found distended with chyle (resembling fine white threads), and can be traced into the glands from all parts of the small intestine.* After

* The arrangement of the chyliferous vessels is well displayed in the plates of Mascagni.

traversing the glands, they all eventually empty their contents into the receptaculum chyli (p. 200).

Superior Mesenteric Artery and Branches. — This large artery arises from the front of the aorta just below the cœliac axis, descends beneath the pancreas, in front of the transverse part of the duodenum (Fig. 162, No. 8, p. 434), and then runs between the layers of the mesentery towards the right iliac fossa, where it terminates in branches for the supply of the cæcum. Thus it describes a gentle curve from left to right. It is crossed by the pancreas and splenic vein, and will be seen to supply the descending and transverse duodenum, the jejunum, ileum, and the ascending and transverse colon. It is accompanied by its corresponding vein, and is surrounded by the superior mesenteric sympathetic plexus. It gives off the following branches: —

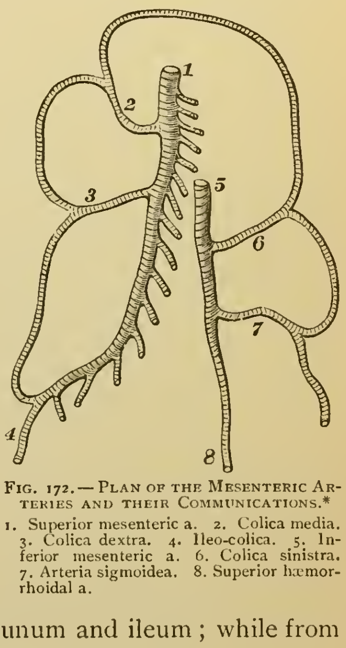


Fig. 172. — Plan of the Mesenteric Arteries and their Communications.*

1. Superior mesenteric a. 2. Colica media. 3. Colica dextra. 4. Ileo-colica. 5. Inferior mesenteric a. 6. Colica sinistra. 7. Arteria sigmoidea. 8. Superior hæmorrhoidal a.

1. The *inferior pancreatico-duodenal* branch, which runs up behind the pancreas, within the concavity of the duodenum, to inosculate with the *superior pancreatico-duodenal* branch of the hepatic.

2. *Vasa intestini tenuis* of the small intestine, from ten to sixteen in number, are given off from the left or convex side of the curve, and are distributed to the jejunum and ileum; while from the concave side come —

3. The *ileo-colic*;

4. The *right colic*, for the supply of the ileum, cæcum, and ascending colon; and

5. The *middle colic*, for the supply of the transverse colon.

The student should now trace the branches to the small intestine, in order to see the series of arches which they form by their mutual inosculations. There are three or four tiers of them, each tier composed of smaller and more numerous

* The inferior pancreatico-duodenal artery is not represented.

branches than the preceding. The ultimate branches ramify in circles round the intestine. This circular arrangement of the vessels in the coats of the bowel is practically interesting, because it enables one in almost all cases to distinguish the intestine from the hernial sac.

The *colic* branches of the superior mesenteric are the *ileo-colic*, which is the continuation of the main trunk, and divides into two branches; one supplies the lower part of the ileum; and the other the cæcum;

The *right colic*, which proceeds towards the ascending colon; and

The *middle colic*, which ascends between the layers of the meso-colon to the arch. They are arranged after the same plan as those of the small intestine; that is, they inosculate and form a series of arches which successively decrease in size, and finally terminate in circles around the bowel.

The *superior mesenteric vein* joins the splenic behind the pancreas, and forms the vena portæ (p. 465).

Dissection of the Inferior Mesenteric Artery and Branches.—To trace this artery, the small intestine must be drawn over towards the right side, and the peritoneum covering the artery removed, since the artery lies behind the peritoneum. It is given off from the front of the aorta, about two inches (*5 cm.*) above its bifurcation, and is surrounded by the inferior mesenteric plexus of sympathetic nerves. Descending towards the left iliac fossa, it crosses obliquely over the left common iliac artery, passes between the layers of the meso-rectum, and taking the name of *superior hæmorrhoidal*, is finally distributed to the upper part of the rectum. Its branches are:—

1. The *colica sinistra*, which crosses behind the peritoneum, over the left kidney, and supplies the descending colon.
2. The *sigmoidea*, which runs over the psoas, is distributed to the sigmoid flexure.
3. The *superior hæmorrhoidal*, which supplies the upper part of the rectum, and will be dissected with the side view of the pelvis.

These branches of the inferior mesenteric inosculate in the form of arches, like the colic branches of the superior mesenteric. The colica sinistra, too, forms a large arterial arch with the colica media, so that there is a chain of arterial communications from one end to the other of the intestinal canal (Fig. 172).

The *inferior mesenteric vein* ascends nearly vertically behind the peritoneum, passes in front of the left psoas, behind the third portion of the duodenum and the pancreas, and joins the splenic behind the pancreas.

Dissection.—To see the relations of the duodenum and the pancreas, two ligatures about an inch (*2.5 cm.*) apart should be

placed on the upper end of the jejunum, and two others at a similar distance apart on the lower end of the sigmoid flexure of the colon. After the jejunum and the sigmoid flexure have been divided between the ligatures respectively, the small and large intestines are to be removed by cutting through the peritoneal folds which connect them to the abdominal walls. By turning up the stomach, we expose the duodenum curving round the great end of the pancreas.

Duodenum, Relations of.—The duodenum (Fig. 170, p. 463) commences at the pyloric end of the stomach, and terminates on the left side of the second lumbar vertebra where the intestinum jejunum begins. It is about eight to ten inches (*20–25 cm.*) in length and two inches (*5 cm.*) in diameter, and is divided into three parts, an ascending, descending, and transverse.

The first portion ascends obliquely as high as the neck of the gall-bladder; then, making a sudden bend, it descends in front of the right kidney as low as the third lumbar vertebra. Lastly, making another bend, it ascends obliquely across the spine to the left side of the second lumbar vertebra; here the intestine takes the name of jejunum. Thus the duodenum describes a horseshoe curve, the concavity of which is directed towards the left side, and embraces the head of the pancreas.

The first or *ascending* portion is about two inches (*5 cm.*) long, and is completely invested by peritoneum. It is comparatively free, so that the movements of the stomach may not be restricted. In front of it are the liver and the neck of the gall-bladder. Behind it are the bile-duct, the hepatic artery, and the vena portæ. The second or *descending* portion is about three inches (*7.5 cm.*) long, and is covered by peritoneum only on its anterior surface. It is firmly connected to the deeper structures behind, and to the pancreas on its left side, so that no movement is permitted in this portion. It descends from the neck of the gall-bladder to the right side of the body of the third lumbar vertebra. It lies behind the transverse colon, in front of the right kidney and the ductus communis choledochus; on the left side it is in relation with the head of the pancreas, its duct, and the superior and inferior pancreatico-duodenal arteries. The third or *transverse* portion, about four inches (*10 cm.*) long, is situated behind the transverse meso-colon, just above the mesentery and the superior mesenteric vessels. Above it are the pancreas, and the superior mesenteric artery

and vein, which pass between the pancreas and the duodenum: behind, it rests upon the crura of the diaphragm, the inferior vena cava, and the aorta. This portion, like the second, is only covered in front by the peritoneum.* Notice how firmly the duodenum is braced up on the left side of the second lumbar vertebra, and how the jejunum begins here by an abrupt downward bend.

Pancreas, Relations of. — The pancreas is a large compound racemose gland, situated immediately behind the stomach (Fig. 170, p. 463). It is of an elongated form, and of pinkish-white color. It is placed transversely across the spine; its larger end, or *head*, is embraced by the duodenum; its lesser end, or *tail*, is in contact with the spleen. It is about six to eight inches (*15 to 20 cm.*) in length, its average breadth is one inch and a half (*3.8 cm.*), and its thickness from half an inch to an inch (*13 mm. to 2.5 cm.*). Its weight is from $2\frac{1}{4}$ oz. to $3\frac{1}{2}$ oz. (*63.7 to 89 gm.*), although it frequently exceeds the latter weight.

In *front*, the gland has the ascending layer of the transverse meso-colon and the stomach: its *right extremity*, or *head*, is embraced by the duodenum, separated from it by the pancreatico-duodenal arteries; *behind* the head is the ductus communis choledochus, whilst the body is in relation posteriorly with the inferior vena cava, the superior mesenteric vein and artery, the aorta, the beginning of the vena portæ, the crura of the diaphragm, the left kidney, the supra-renal capsule, and the inferior mesenteric vein; its *left extremity*, or *tail*, touches the concavity of the lower surface of the spleen, and is in front of the left supra-renal capsule; the *upper border* is in relation with the cœliac axis, the splenic artery and vein lying in a groove in the gland, and on the right side with the ascending portion of the duodenum and the hepatic artery; the *lower border* is in relation with the transverse portion of the duodenum, from which it is separated by the superior mesenteric vessels, and to the left side with the inferior mesenteric vein.

Its *duct* (*canal of Wirsung*) runs from left to right, near the lower border and anterior surface of the gland, and empties itself into the back part of the descending portion of the

* Recent authors have called that portion of the transverse portion covered ventrally and laterally by peritoneum the *second ascending portion*. This, from its position, contour, and peritoneal relations, belongs to the duodenum and not the jejunum; it is always to the left of the vertebral column, denoting the original position of the gut in the embryo. — A. H.

duodenum, conjointly with, or close to, the opening of the common bile-duct. It receives numerous branches from the splenic artery, which runs along its upper border; some from the superior mesenteric, which lies immediately beneath it, and others from the gastro-duodenalis.

Dissection. — The liver, stomach, duodenum, pancreas, and spleen should now be collectively removed. For this purpose it is necessary to cut through the ligaments of the liver, the venæ cavæ hepaticæ, and the branches of the cœliac axis. These viscera, with the remainder of the intestinal canal, should be macerated in water, while you examine all that is to be seen at the back of the abdomen: namely, the deep-seated muscles, the aorta, the inferior vena cava, the kidneys, the lumbar plexus of nerves, and the sympathetic nerve.

Kidneys and Ureter, Relations of. — The kidneys, two large glands which excrete the urine, are situated in the lumbar region, enveloped by a capsule of loose areolar tissue (the meshes of which are at certain points filled with a soft fat), behind the peritoneum, one on each side of the spine. They extend from the eleventh rib nearly as far as the crest of the ilium, and lie embedded in more or less fat, on the quadratus lumborum, the psoas, and the crura of the diaphragm. The adult kidney is 4.4 inches (*11 cm.*) in length, 2 inches (*5 cm.*) wide, and 1 inch (*2.5 cm.*) in thickness. It weighs in the male 4 to 6 oz. (*113.5 to 170 gms.*), in the female 4 to $5\frac{1}{2}$ oz. (*113.5 to 156 gms.*). Surmounting each is a small body, called the supra-renal capsule.

The *anterior surface* is convex, and the right kidney has *in front* the liver, the ascending colon, the descending portion of the duodenum, and the colica dextra artery; the left kidney has *in front* the lower part of the spleen, the cardiac end of the stomach, the descending colon, the tail of the pancreas, and the colica sinistra artery. This explains how it is that a renal abscess or calculus is sometimes evacuated by the rectum. *Above*, the right kidney is in contact with the under surface of the liver, and its upper end reaches as high as the lower border of the eleventh rib; the left kidney is in contact above with the spleen, and reaches to the level of the upper border of the eleventh rib. The *posterior surface* is flat and lies on the corresponding crus of the diaphragm, the quadratus lumborum, and the psoas, separated, however, by the anterior layer of the aponeurosis of the transversalis; the *outer border* is convex, and

looks towards the parietes; the *inner border* presents a deep notch, the *hilum*, continuous with a cavity, the *sinus*, through which pass the renal artery and vein, the ureter, the renal plexus of nerves and lymphatics, surrounded by connective tissue and fat. The vessels and duct have the following relations: anteriorly is the renal vein, posteriorly is the ureter, the renal artery being between them. The ureter descends almost vertically on the psoas muscle, enters the pelvis over the division of the common iliac artery, and empties itself into the lower part of the bladder after running obliquely through its coats.

Dissection. — The kidney, below, descends nearly as low as the crest of the ilium, and is not so broad as the upper extremity. The kidneys and supra-renal capsules must be removed and reserved for further examination.

Semilunar Ganglia. — The *semilunar ganglia*, two in number, are contained in the solar plexus, and are situated one on each side of the cœliac axis, in the neighborhood of the supra-renal bodies; that on the right side will be found lying under the vena cava inferior. They consist of irregular ganglionic masses. Above, each ganglion receives the great splanchnic nerve (Fig. 75, p. 205), and the two ganglia are connected on their inner sides. Filaments are distributed to the supra-renal and renal plexuses and to the plexuses which surround the branches of the abdominal aorta. The branches of the solar plexus will be described later on.

Diaphragm. — This is a partly muscular and partly tendinous arch, so constructed as to form a complete movable partition between the chest and the abdomen: a floor for the one, and a roof for the other. Its upper or thoracic surface is convex; its lower or abdominal, concave. On removing its peritoneal coat, and a thin fascial covering from the transversalis fascia, we observe a broad tendon in the centre, and that muscular fibres converge to it from all sides (Fig. 173). The diaphragm *arises*, 1. From the ensiform cartilage by fleshy fibres; 2. From the inner surfaces of the cartilages of the six lower ribs by as many digitations, which correspond with those of the transversalis; 3. From two thin tendinous arches, called, respectively, the *ligamenta arcuata, externum* and *internum* (the external arch is the thickened upper border of the anterior layer of the transversalis fascia, and extends from the last rib to the transverse process of the first lumbar vertebra, and arches over

the quadratus lumborum ; the internal passes from the transverse process of the first lumbar vertebra to the body of the same vertebra, and arches over the psoas) ; and 4. From the front of the bodies of the lumbar vertebræ by two elongated bundles, called the *crura* of the diaphragm. Both crura have tendinous origins ; the right crus is, however, a little longer than the left ; the former arises from the first, second, and third lumbar vertebræ and their intervening cartilages ; the left does not descend so low by one vertebra. The inner fibres of each crus decussate, those of the right being the more anterior. In their

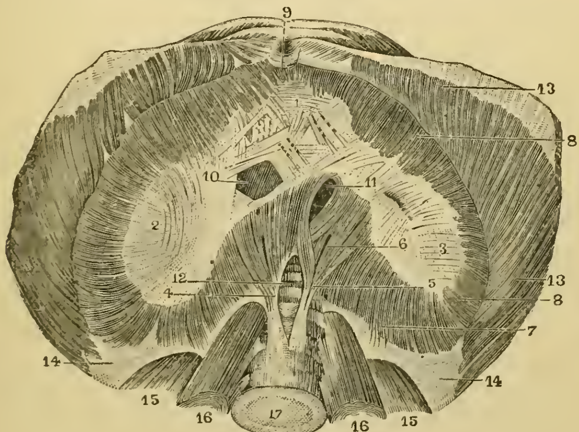


FIG. 173.—THE DIAPHRAGM.

1. Anterior or middle leaflet of the central aponeurosis. 2. Right leaflet. 3. Left leaflet. 4. Right crus. 5. Left crus. 6. Slit for the great splanchnic nerve. 7. Muscular fibres which arise from the arcuate ligament. 8, 8. Fibres which arise from the cartilages. 9. Fibres which arise from the base of the ensiform cartilage. 10. Opening for the vena cava. 11. Œsophageal opening. 12. Aortic opening. 13. Superior part of the transversalis m. turned back. 14, 14. Aponeurosis of the transversalis. 15, 15. Quadratus lumborum m. 16, 16. Psoas magnus m. 17. Third lumbar vertebra.

decussation the fibres separate the aortic from the œsophageal openings. Between the two crura the aorta enters the abdomen.

From these various origins the fibres ascend, at first nearly vertically, and then all arch inwards, and converge to be *inserted* into the central tendon.

The *central tendon* is nearly the highest part of the diaphragm. It presents a white, glistening surface, owing to the crossing of its tendinous fibres ; its shape may be compared to that of a trefoil leaf, and it is composed of a right and left leaflet and a middle leaflet, separated from each other by indentations. Of the three leaflets, the right is the largest and the left the

smallest. The chief point of interest about the tendon is that, in consequence of its connections with the pericardium, below which it lies (Fig. 71, p. 188), it is always maintained on the same level; so that it helps to support the heart, and serves as a fixed point for the insertion of the muscular fibres of the diaphragm.

Openings in the Diaphragm. — There are three large openings in the diaphragm for the transmission of the aorta, the œsophagus, and the inferior vena cava, respectively, and several smaller apertures for the transmission of nerves and vessels. The *aortic opening* is osseo-aponeurotic, and lies in the middle line between the two crura in front of the spine; it transmits, also, the vena azygos major and the thoracic duct, both of which lie rather to the right side of the aorta. Trace the crura upwards, and observe that the inner fibres of each cross each other in front of the aorta, somewhat like the letter X.* Above the decussation, and a little to the left of it, is the *œsophageal opening*; this is oval and entirely muscular, and transmits the œsophagus and the pneumogastric nerves. The *opening* for the *vena cava* (*foramen quadratum*) is situated in the highest part of the central tendon, rather to the right of the middle line, and is quadrate in shape. Through this opening pass the inferior vena cava, some lymphatics from the convex surface of the liver, and usually a branch from the right phrenic nerve. Observe that the vein is intimately connected to its margin, and kept permanently open. Lastly, there pass *through the crus*, on each side, the sympathetic and the greater and lesser splanchnic nerves; and in addition, on the left side, the vena azygos minor. The arch of the diaphragm, in expiration, extends about as high as the fifth rib on the right side and the sixth rib on the left.

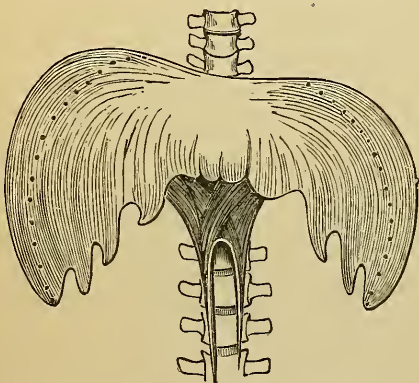


Fig. 174. — Diaphragm, from its Upper Surface.
(The dotted lines show the amount of descent on contraction.)

* This decussation is not always complete. But the right crus always crosses more or less over the left, so that the crura are never strictly parallel.

The nerves of the diaphragm are the phrenic (p. 197), and the five or six lower intercostal nerves. The diaphragm also receives minute filaments from the diaphragmatic plexuses, which come from the semilunar ganglia. On its under surface, on the right side, close to the supra-renal capsule, the plexus joins some branches of the right phrenic nerve, at which spot there is a small ganglion (*ganglion diaphragmaticum*), from which filaments are given off to the liver, vena cava, and supra-renal capsule. It is absent on the left side. Its blood-vessels are the two phrenic, derived from the aorta, the internal mammary (p. 171), and the lower intercostal.

Function of the Diaphragm. — The diaphragm is the great muscle concerned in inspiration. During inspiration the muscular sides of the diaphragm contract, and become less arched (as shown by the dotted line in Fig. 174); the floor of the chest sinks in consequence, and more room is made for the expansion of the lungs. During expiration the diaphragm relaxes and the air is expelled, partly by the elasticity of the lungs and the thoracic walls, partly by muscular action. This alternate sinking and rising of the diaphragm constitutes a chief part of the mechanism of breathing. But the diaphragm conduces to the performance of many other functions. Acting in concert with the abdominal muscles, it assists in the expulsion of the fæces and the urine, also in parturition and in vomiting; for in all these operations we first take in a deep breath, that the diaphragm may be in a state of contraction, and so form a resisting surface, against which the viscera may be compressed by the abdominal muscles. Moreover, by its rapid or spasmodic contractions it is one of the chief agents concerned in laughing, sneezing, coughing, hiccough.

Dissection. — The student should now dissect the large vessels and the muscles of the back part of the abdomen. To do so, the mesentery which lies in front of the aorta and vena cava is to be removed, as well as the fat and connective tissue. The dissection should include the parietal branches of the abdominal aorta; afterwards, its great primary divisions — the common and external iliac arteries — should be cleaned as far as Poupart's ligament. The quadratus lumborum, the psoas, and iliacus muscles should be carefully cleaned, care being taken not to injure the nerves and arteries lying in front of them; thus, in front of the quadratus lumborum are the last thoracic, the ilio-hypogastric, and ilio-inguinal nerves, which cross the muscle obliquely; in front of the iliacus are the external cutaneous and anterior crural nerves; and coming through, and then lying in front of the psoas, is the genito-crural nerve, while to the inner side of the muscle is the obturator nerve. The gang-

liated cord of the sympathetic nerves, situated on each side of the bodies of the vertebræ, must also be made out; and, lastly, the sheath which invests the psoas should be examined, and the branches of the lumbar plexus preserved as they emerge from beneath the outer border of the muscle.

Before examining the course of the aorta, notice that a chain of lymphatic glands extends along the brim of the pelvis and the bodies of the lumbar vertebræ, following the course of the great blood-vessels. Generally speaking, they are small; only one here and there attracts observation. They transmit the lymphatics from the lower limbs, the abdominal wall, and the testicle; and all eventually lead to the *receptaculum chyli*, or beginning of the thoracic duct (Fig. 74, p. 199). This is usually found on the right of the aorta, close to the second lumbar vertebra.

Course and Relations of the Abdominal Aorta. — The *abdominal aorta* enters the abdomen between the crura of the diaphragm in front of the body of the last thoracic vertebra, and descends a little to the left side of the front of the spine, as low as the middle of the fourth lumbar vertebra, where it divides into the two common iliac arteries. It follows the curve of the lumbar convexity, attaining its greatest curve on a level with the third lumbar vertebra. It rapidly lessens in size, owing to the large branches it gives off in its course. The division of the aorta into the two common iliac arteries is about the level of the highest point of the crest of the ilium, and just below the left side of the umbilicus. The artery has *in front* of it, the stomach and the lesser omentum, the solar plexus surrounding the cœliac axis, the splenic vein, the pancreas, the transverse portion of the duodenum, the left renal vein, the mesentery, the aortic sympathetic plexus, and a chain of lymphatic glands. To the *right side* of it, lie the right crus of the diaphragm, the inferior vena cava, the thoracic duct, the vena azygos, and the right semilunar ganglion. To the *left side* of it, are the left crus, the left semilunar ganglion, and the sympathetic nerves. *Behind*, it rests on the receptaculum chyli, the thoracic duct, the left lumbar veins, and the anterior common ligament.

The branches of the aorta still to be examined arise from it in pairs — namely, the phrenic, capsular, renal, spermatic, and lumbar (Fig. 175).

Phrenic Arteries. — These arteries supply the under surface of the diaphragm, and occasionally arise separately, usually by a common trunk, from the aorta, after its passage under the crura of the diaphragm (Fig. 175). The *right phrenic*

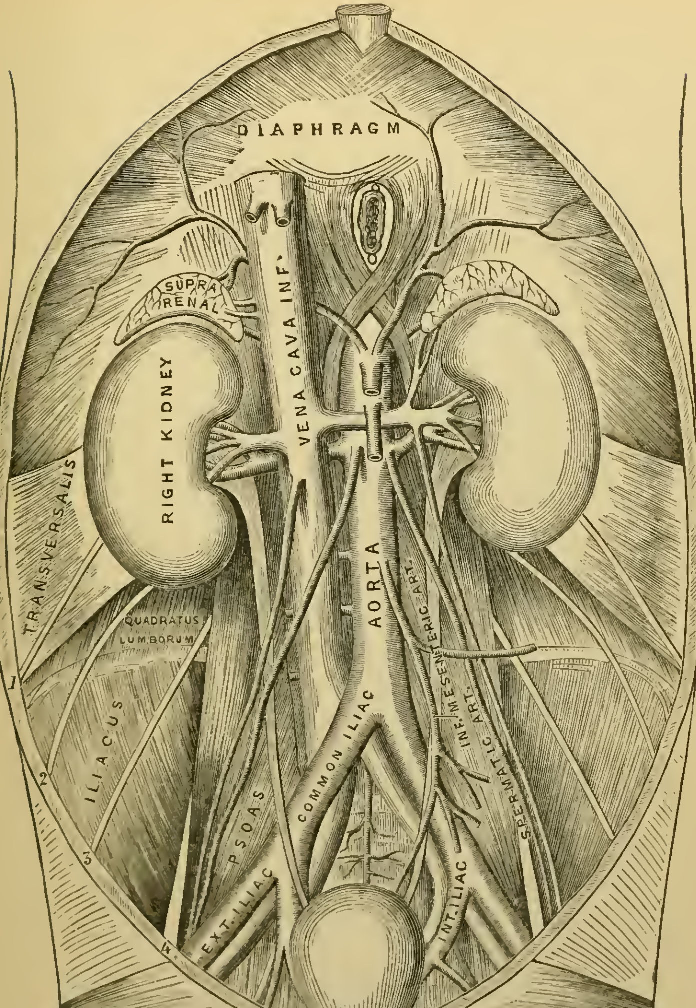


FIG. 175.—DIAGRAM OF THE COURSE AND RELATIONS OF THE ABDOMINAL AORTA AND VENA CAVA INFERIOR.

1. Ilio-hypogastric nerve. 2. Ilio-inguinal n. 3. External cutaneous n. 4. Anterior crural n.

passes outwards, behind the liver and inferior vena cava, and then gets to the right side of the caval opening in the diaphragm; the *left phrenic* ascends behind the œsophagus, and gets to the left side of the œsophageal opening. Each ascends, lying on its corresponding crus, as far as the central tendon, where it di-

vides into two branches: one, the external, passes transversely across the tendon to the side of the diaphragm; the other, the internal branch, which seems to be the continuation of the artery, runs forward to the anterior part of the muscle. Their first branches are to the supra-renal capsules: then, the internal branch of the right gives off a small branch to the vena cava, the corresponding branch of the left sends one to the œsophagus. Moreover, small branches are distributed respectively to the liver and to the spleen. They inosculate with each other, with the musculo-phrenic branches of the internal mammary, and the intercostal arteries. The *right phrenic vein* terminates in the inferior vena cava; the *left vein* in the renal vein, if not in the vena cava.

Supra-renal Arteries. — The *supra-renal* or *capsular arteries* are two very small branches, given off from the aorta, one on each side, opposite to the superior mesenteric artery; each runs upon the crus of the diaphragm, the right behind the inferior vena cava, and is distributed to the supra-renal body, inosculating with branches from the renal and phrenic arteries. The *right capsular vein* terminates in the inferior vena cava, the *left* in the left renal vein.

Renal Arteries and Veins. — The *renal arteries* arise from the aorta immediately below the superior mesentery artery, and run transversely to the hila of the kidneys. Both are covered by their corresponding veins. The right is longer and rather lower than the left, and passes behind the vena cava. Each, after sending a small branch to the supra-renal body and ureter, enters its kidney, not as a single trunk, but by several branches, corresponding to the original lobes of the organ. The *renal veins* lie in front of the arteries, and join the vena cava at right angles. The left is longer than the right, and crosses over the aorta; it also receives the spermatic, capsular, and the phrenic veins of its own side.

Spermatic Arteries and Veins. — The *spermatic arteries*, two in number, arise from the front of the aorta, a little below the renal, and pass to the testes in the male and to the ovaries in the female. Each runs down behind the peritoneum, obliquely over the psoas, crossing over the ureter, and the front of the external iliac artery immediately above the crural arch; the right artery in addition lying over the vena cava. Each then passes through the internal abdominal ring and inguinal canal, with the other constituents of the spermatic cord, to the testicle, where it becomes tortuous and divides into several branches, some of which accompany the vas deferens and supply the epididymis; others supply the testis by piercing the tunica albuginea. Each artery is accompanied, below the external abdominal ring, by a very convoluted plexus of veins — *pampiniform plexus*. At the inner ring they terminate in two tortuous veins, which unite before they empty themselves, on the *right* side, obliquely, into the vena cava; on the left side at right angles, into the left renal vein, after passing behind the sigmoid flexure of the colon. In the female the *ovarian arteries* descend towards the pelvis, and lie between the two layers of the broad ligament to be distributed to the ovaries, some branches also going to the Fallopian tubes, and one to the side of the uterus to anastomose with the uterine artery of the internal iliac. They likewise send small offsets to the round ligament, and thence to the skin of the pubes and groins.

Lumbar Arteries and Branches. — There are usually five of these arteries on each side; four arise from the back of the aorta, the fifth comes from the arteria sacra media. They are analogous to the intercostal arteries on a small scale. They proceed outwards over the bodies of the vertebræ beneath the sympathetic nerve and the arches formed by the psoas muscle; the two upper pass beneath the crura of the diaphragm; those on the right side being also behind the vena cava inferior. Passing towards the intervertebral foramina, they, like the intercostals, divide into thoracic and abdominal branches.

The *thoracic branches* pass between the transverse processes of the vertebræ, accompanied by the posterior branches of the corresponding nerves, and are of a size proportionate to the large development of the muscles of the back, which they supply. They also send *spinal branches*, which enter the spinal canal through the intervertebral foramina; some of these are distributed to the anterior part of the

cauda equina, and others to the bodies of the lumbar vertebræ, forming a series of arches behind them.

The *abdominal branches* all run outwards behind the quadratus lumborum, except the last, which usually runs in front. After supplying the quadratus and psoas they pass forwards between the abdominal muscles and supply the walls of the abdomen.* They anastomose, *laterally*, with the ilio-lumbar and circumflex iliac arteries; *in front*, with the internal mammary and epigastric arteries; and *above*, with the intercostals.

The *lumbar veins* empty themselves into the vena cava inferior, the left passing behind the aorta.

The *arteria sacra media*, a diminutive continuation of the aorta, proceeds from its bifurcation, and runs down, behind the left common iliac vein and in front of the sacrum, to the coccyx. It sends off the fifth lumbar artery and lateral branches, which anastomose with the lateral sacral arteries; it also supplies small vessels to the posterior part of the rectum, which runs forwards between the layers of the meso-rectum. In close connection with the terminal branch of this artery at the tip of the coccyx is a small, roundish body called the *coccygeal* or *Luschka's gland*.† It is about the size of a pea, and is placed between the levatores ani and the sphincter ani. It is probably composed of a plexus of small arteries, which are surrounded by one or more layers of granular polygonal cells. The body itself is invested by connective tissue, in which also some branches from the ganglion impar have been traced. This gland should be considered as an arterial gland, of which the intercarotic ganglion is another example.

The *vera sacra media* empties itself into the left common iliac vein.

Vena Cava Inferior. — The *vena cava inferior* is formed by the junction of the two common iliac veins, a little to the right side of the intervertebral cartilage between the fourth and fifth lumbar vertebræ. It ascends in front of the spine, in the greater part of its course lying to the right of the aorta. As it approaches the diaphragm, the vena cava inclines a little to the right, separated from the aorta by the right crus of the diaphragm. It is then received into a deep groove on the posterior border of the liver, and afterwards passes through the tendinous opening in the diaphragm to reach the right auricle of the heart. Its relations, beginning from below, are — *in front*, the mesentery, the third part of the duodenum, the pancreas, the right spermatic artery, the portal vein, and the liver; *behind* it are the right renal artery, the right lumbar arteries, the sympathetic of the right side, and the right phrenic artery; on its *left*, is the aorta, and higher up the right crus. It receives the lumbar veins, the right spermatic (the left joins the renal), the renal, the right supra-renal, the right phrenic, and the hepatic veins,

* Just as the thoracic intercostals, by communicating with the internal mammary, form an arterial ring round the chest, so do the lumbar, by communicating with the epigastric, form a similar, though less perfect, ring round the walls of the abdomen.

† Callender, *British Medical Journal*, June 13, 1874.

which are usually three in number, one each from the right and left lobes, and one from the lobulus Spigelii.

The student should now direct his attention to the three large muscles which are seen at the back of the abdomen: the quadratus lumborum situated between the last rib and the crest of the ileum; the iliacus occupying the iliac fossa; and the psoas magnus passing from the sides of the lumbar vertebræ, along the brim of the pelvis, and beneath Poupart's ligament, to be inserted into the lesser trochanter of the femur. The nerves should at the same time be cleaned, and, if more convenient, the student might dissect the muscles on one side, and the nerves and arteries on the other.

Psoas Fascia. — The fascia covering the iliacus and psoas muscles is seen to be thin above and thicker below. It consists of two portions, the psoas and the iliac fascia. The *psoas fascia* is attached to the sides of the lumbar vertebræ and their intervertebral cartilages, internally to the sacrum, and above to the ligamentum arcuatum internum; externally it is thinner, and is continuous with the fascia lumborum. It is this sheath which determines the ordinary course of a psoas abscess — namely, beneath the crural arch into the upper part of the thigh; for it is a rare exception when the pus travels into the pelvis.

Iliac Fascia. — The *iliac fascia* covers the iliacus muscle, and is attached to the inner lip of the crest of the ilium, and to the brim of the pelvis, through its connection with the sheath of the psoas and the tendinous insertion of the psoas parvus. Its most important attachment is to the outer half of the crural arch, and it is here directly continuous with the fascia transversalis (Fig. 162, p. 434), so that together they present an effectual barrier to the escape of intestine beneath this part of the arch.* On the inner half of Poupart's ligament these two fasciæ are separated by the femoral vessels, so that the fascia transversalis lies in front of, the fascia iliaca behind the artery and vein, thus forming their sheath as they pass down the thigh. This portion of the iliac fascia also forms a sheath for the psoas and iliacus as far as their insertion, and becomes

* The iliac fossæ are liable to be the seat of suppuration, and the course which the pus takes depends upon its position with regard to the iliac fascia. If the pus be seated in the loose cellular tissue between the peritoneum and the fascia, it usually advances just above the crest of the ilium, or towards the groin through the inguinal canal; but, if seated beneath the fascia, the pus usually makes its way under the crural arch towards the upper and outer part of the thigh.

continuous with the iliac portion of the fascia lata. Internally the iliac fascia is attached to the linea ilio-pectinea, where it becomes continuous with the pubic portion of the fascia lata. The external iliac artery and vein lie in front of the fascia, while the anterior crural nerve is behind it.

These fasciæ are now to be dissected off, when the psoas and iliacus will be completely exposed.

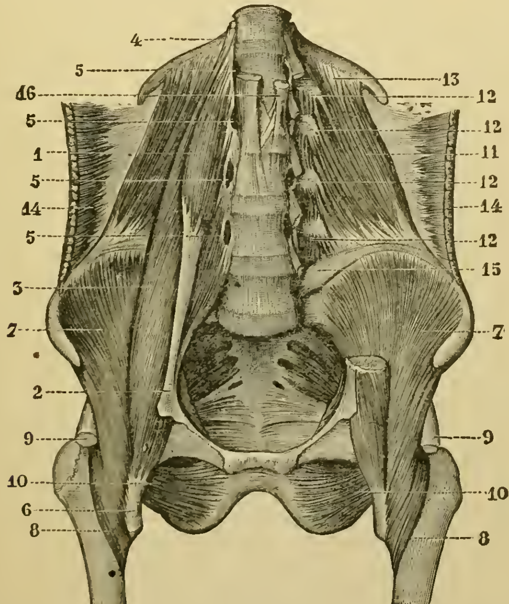


FIG. 176.—PSOAS, ILIACUS, AND QUADRATUS LUMBORUM MUSCLES.

1. Psoas parvus. 2. Its tendon cut at its attachment to iliac fascia. 3. Psoas magnus. 4. Its origin from the body of the twelfth thoracic vertebra. 5, 5, 5, 5. Its origin from the four lumbar vertebræ, showing the fibrous arch for each. 6. Tendon of insertion to the lesser trochanter. 7, 7. Iliacus. 8, 8. Inferior and external fibres, inserted on an anterior plane below the lesser trochanter. 9, 9. Rectus femoris. 10, 10. Obturator externus. 11. Quadratus lumborum. 12, 12, 12, 12. Posterior fasciculi attached to the transverse processes of the four upper lumbar vertebræ; the long fasciculi covering these processes have been removed, to allow the posterior to be seen. 13. The external fasciculi larger than the posterior are inserted into the twelfth rib by a short aponeurosis. 14, 14. Transversalis. 15. Ilio-lumbar ligament. 16. The two crura of the diaphragm.

Psoas Magnus.—This long muscle *arises* by five muscular fasciculi from the transverse processes of all the lumbar vertebræ, also from the bodies of the last thoracic and all the lumbar vertebræ and their intervening fibro-cartilages, but only from the projecting borders of their bodies, not from the central concave part; here the fibres arise from tendinous arches thrown

over the lumbar vessels. The muscle descends vertically along the brim of the pelvis, beneath or dorsad to the crural arch into the thigh, and is *inserted* by a strong tendon into the back part of the lesser trochanter of the femur. *Ventrally*, the psoas has in relation with it the psoas fascia, the ligamentum arcuatum internum, the common and external, iliac artery and vein, the kidney and ureter, the spermatic vessels, the genito-crural nerve, the colon, the renal vessels, the vas deferens, the psoas parvus when present; *dorsad* to it are the ilium, the transverse processes of the lumbar vertebræ, the quadratus lumborum, the anterior or ventral layer of the transversalis aponeurosis, the lumbar plexus of nerves, and the obturator nerve, which lower down runs along the mesial border of the muscle; *mesially* are — the crus of the diaphragm, the bodies of the lumbar vertebræ, the lumbar arteries, the lumbar glands, and the sympathetic nerves; mesially the left psoas is the aorta, and to that of the right psoas is the inferior or caudal vena cava. Towards its insertion the tendon of the psoas lies between the iliacus and pectineus. The *action* of the muscle considered with the femur vertical, or nearly so, and horizontal, or femur flexed at 90°, during flexion, perform the following: VERTICAL. External or lateral rotation its natural position; internal or mesial rotation; external or lateral rotation during adduction from position of abduction; internal or mesial rotation during abduction; adduction; abduction during adduction; abduction during internal or mesial rotation; adduction during external or lateral rotation; flexion. HORIZONTAL or femur flexed at 90° external or lateral rotation; internal or mesial rotation; adduction; flexion. DURING FLEXION, external or lateral rotation; internal or mesial rotation during internal or mesial rotation.*

As it passes under or dorsad to the crural arch, the tendon of the psoas lies immediately over or ventrad to the capsule of the hip-joint, and there is a large bursa between them to facilitate the play of the tendon. It should be borne in mind that occasionally, even in young subjects, but more frequently in old ones, in consequence of wear and tear, this bursa communicates with the hip-joint. The fact is important, for it explains how a psoas abscess sometimes makes its way into the hip-joint, a result frequently fatal.

* Prize essay on "Rotators of the Femur and their other Functions," *Phil. Med. Jour.*, 1. 1. '99. Dr. Eb. H. Thomas, of Philadelphia.

Psoas Parvus. — Once in about eight or ten subjects there is a small muscle called the *psoas parvus* placed superficially to the preceding muscle. It *arises* from the sides of the bodies of the last thoracic and the first lumbar vertebræ, and the intervening fibro-cartilage; thence, descending in front, and to the inner side of the psoas magnus, it ends in a long flat tendon, which spreads out, and is *inserted* into the linea ilio-pectinea.

Iliacus. — The iliacus *arises* from the iliac fossa, the inner lip of the crest of the ilium, the ilio-lumbar ligament,* the base of the sacrum, and the anterior superior spine of the ilium; below, also from the anterior inferior spine and from the capsule of the hip-joint. The fibres converge beneath to the crural arch, and are *inserted* mainly into the outer side of the tendon of the psoas, and partly into the triangular surface of the femur, below and anterior to the lesser trochanter. Thus the two muscles, so far as their action goes, may be considered as one, and are sometimes called the ilio-psoas.

The iliacus in the abdomen is in relation, *ventrally*, with the iliac fascia, the external cutaneous and crural nerves, with the cæcum on the right, and with the sigmoid flexure on the left side; *dorsally*, it is in contact with bone; on its *mesial side* is the psoas. In the thigh it is in relation, *ventrally*, with the rectus, the sartorius, the fascia lata, the crural nerve, the profunda femoris, and the external circumflex arteries; *dorsally*, with the capsular ligament of the hip-joint; on the *mesial side*, with the psoas; and on the *lateral* with the crureus and vastus internus muscles.

The combined *action* of the psoas and iliacus is to assist in raising the body from the recumbent position, and to fix the pelvis steadily on the thigh; this supposes the fixed point to be at the trochanter minor. The action of the iliacus, considered in the vertical or hanging position, and horizontal or flexed at 90°, during flexion, performs the following: VERTICAL. Internal or mesial rotation; abduction; flexion. HORIZONTAL or femur flexed at 90°; neutral, opposing slightly abduction and adduction; internal or mesial rotation; external or lateral rotation; flexion. DURING FLEXION, mesial rotation; external rotation when preceded by external rotation of about 30°.

Quadratus Lumborum and its Sheath. — This quadrilateral muscle extends from the crest of the ilium to the last rib,

* This ligament extends from the transverse process of the last lumbar vertebræ to the ilium.

and is contained in a sheath formed for it by the aponeurotic origin of the transversalis (Fig. 176). The anterior layer of its sheath is attached to the roots of the *transverse* processes of the lumbar vertebræ, and the posterior layer to their summits. The muscle, broader below than above, *arises* by two portions* — one from the ilio-lumbar ligament and from the crest of the ilium for two inches (*5 cm.*) external to it, and is *inserted* into the last rib, and by tendinous slips into the apices of the transverse processes of the upper four lumbar vertebræ; the other portion of the muscle arises from the transverse processes of the third, fourth, and fifth lumbar vertebræ, and is inserted into the lower margin of the last rib, in front of the preceding portion. The principal use of the muscle is to steady the spine; it also steadies the last rib, and enables it to serve as a fixed point for the action of the intercostal muscles and the diaphragm.†

By raising the quadratus, we observe the aponeurotic origin of the transversalis from the summits of the transverse processes; this constitutes the posterior part of its sheath, and separates the muscle from the erector spinæ.

Action of Quadratus Lumborum. — This muscle acting from the pelvis will draw down the last rib, and also laterally flex the thorax; the rib being fixed it will flex the pelvis laterally on the vertebral column. — A. H.

Common Iliac Arteries and Veins. — The abdominal aorta divides, in front of the left side of the fourth lumbar vertebra, into two great branches, termed the *common iliac arteries*. They diverge at an acute angle, and after a course of about two inches (*5 cm.*) downwards and outwards, each divides, over the sacro-iliac symphysis, into the external and internal iliac arteries. They lie upon the bodies of the fourth and fifth lumbar vertebræ. The right common iliac is rather larger than

* Testut and some American teachers describe this muscle in three portions, i.e., "*ilio-costal*" *portion* from the crest of the ilium to the last rib; "*ilio-transverse*" *portion* from the ilio-lumbar ligament to the transverse processes of first, second, and third lumbar vertebræ; "*costo-transverse*" *portion* from the last rib to the transverse processes of second, third, fourth, and fifth lumbar vertebræ. — A. H.

† The respective attachments of the quadratus lumborum, the crossing of its fibres, and its mode of action, lead to the inference that it is a large intercostal muscle. It is worth remembering that the outer edge of the quadratus lumborum, in a well-grown adult, is about three inches (*7.5 cm.*) from the spines of the lumbar vertebræ, and midway between the last rib and the crest of the ilium. It is just outside the edge of this muscle that we can cut down to open the large bowel without wounding the peritoneum.

the left. They are covered *in front* by peritoneum, they are crossed by branches of the sympathetic to form the hypogastric plexus, and they are crossed at or near their division by the ureters; on the *outer side* they are in relation with the psoas. So far, then, the relations of both common iliac arteries are similar. But each has its special relations as follows:—

The *special relations* of the *right common iliac* are, that it has *behind* it the two common iliac veins, which separate it from the fifth lumbar vertebra; on its *outer side*, it has, above, the inferior vena cava; below, the right common iliac vein.

The *special relations* of the *left common iliac* are, that it has *in front* of it the end of the sigmoid flexure of the colon, and the superior hæmorrhoidal artery; and to its *inner side*, the left common iliac vein, which gradually gets more behind it towards the sacro-iliac symphysis.

The relations of these arteries with regard to their corresponding veins are practically important in reference to the operation of tying them. This operation is, obviously, easier on the left side than the right.*

If the common iliac artery were ligatured, the collateral circulation would be maintained through the following vessels: by the internal mammary anastomosing with the deep epigastric a.; by the lumbar arteries with the circumflex iliac and the ilio-lumbar a.; by the lumbar with the gluteal; by the middle sacral with the lateral sacral a.; by the spermatic with the deferential, cremasteric, external pudic, and superficial perineal arteries; by the superior hæmorrhoidal with the middle and inferior hæmorrhoidal a.; by the lower intercostals with the epigastric a. (superficial and deep); and by the middle and inferior hæmorrhoidal, the pudic and its branches, and the vesical arteries communicating in the middle line with the corresponding branches of the opposite side.

External Iliac Artery. — The *external iliac artery*, the continuation of the preceding artery, passes along the brim of the pelvis, first on the inner side, and then in front of the psoas.

* The length of the common iliac artery is apt to vary in different persons. We have seen it from three-fourths of an inch to three and a half inches (*18 mm. to 8.8 cm.*) long. These varieties may arise either from a high division of the aorta, or a low division of the common iliac, or both. It is impossible to ascertain, beforehand, its length in any given instance, as there is no necessary relation between its length and the height of the adult individual. It is often very short in men of tall stature, and *vice versa*. The left is usually described as rather longer than the right; but, from the examination of one hundred bodies, our conclusion is that their average length is the same.

Lower down it passes under the crural arch, midway between the anterior superior spine of the ilium and the symphysis pubis, where it takes the name of femoral. The artery has *in front* of it, the peritoneum, the intestines, and a sheath derived from the iliac fascia investing the artery and the vein; it has also the spermatic vessels in front, and it is crossed by a branch of the genito-crural nerve, the deep circumflexa ilii vein, and the vas deferens; *behind*, it is in relation with the psoas magnus and corresponding vein, which lies also on the inner side of the artery; the iliac fascia also lies behind the vessels, but a thin layer of fascia derived from it is continued over them; *internally*, it has the corresponding vein, and low down, towards Poupart's ligament, the vas deferens; *externally*, it has the psoas magnus and the iliac fascia. In front of and on the inner side of the artery is a chain of lymphatic glands.

The branches given off by this artery are:—

a. Small branches to the psoas and lymphatic glands.

b. The *deep epigastric*, already described (p. 435).

c. The *deep circumflexa ilii*, which arises from the outer side of the artery, just above the crural arch, and, ascending upwards towards the anterior superior spine of the ilium in a sheath formed by the fascia iliaca, runs along the inner aspect of the iliac crest, and subsequently perforates the transversalis muscle.* In the dissection of the abdominal muscles (p. 436), the continuation of it was seen skirting the crest of the ilium between the internal oblique and the transversalis, and sending a branch upwards between these muscles for their supply. The main trunk, much reduced in size, inosculates with the ilio-lumbar derived from the internal iliac.

Sympathetic Nerve.—The general plan upon which the sympathetic nerve is arranged has been noticed in the dissection of the neck (p. 172). The lumbar portion of it must now be examined.

The lumbar portion of the sympathetic descends on each side in front of the bodies of the lumbar vertebræ, along the inner border of the psoas. The nerve has an oval ganglion of grayish color opposite each lumbar vertebra, so that there are either four or five of them on each side. These ganglia are connected together by small filaments of a white color, and each ganglion receives, on its outer side, two branches from the corresponding spinal nerve, as in the chest; other branches pass inwards, and form in front of the aorta — the *aortic plexus;* and some pass downwards over the common iliac arteries to form the hypogastric plexus.

* The course of this artery should be borne in mind in opening iliac abscesses.

Solar Plexus and the Semilunar Ganglia. — The *solar* or *epigastric plexus* is situated in front of the aorta, and surrounds the cœliac axis in a dense network of nerve filaments, in which are several ganglia. It receives the great splanchnic nerves, part of the lesser splanchnic, and some branches from the pneumogastric nerves. The solar plexus gives off filaments which form plexuses surrounding the various branches of the abdominal aorta, and are as follows: —

Diaphragmatic.	Supra-renal.
Cœliac.	Renal.
Gastric.	Spermatic.
Hepatic.	Superior mesenteric.
Splenic.	Inferior mesenteric.
Hypogastric.	

The *diaphragmatic plexus* is derived from the upper part of the semilunar ganglion, and is larger on the right than on the left side. It joins with some filaments of the phrenic nerve, and whilst in relation with the supra-renal body it gives off some branches to it. The right plexus has a small ganglion in it — *diaphragmatic ganglion* — and sends off filaments to the vena cava inferior and to the hepatic plexus.

The *cœliac plexus* receives branches from the lesser splanchnic nerve, and, on the left side, it receives a filament from the right pneumogastric nerve. It divides into the gastric, hepatic, and splenic plexuses, which ramify on the corresponding arteries and their branches; the *gastric plexus* receives in addition filaments from the pneumogastric nerves; the *hepatic plexus*, the largest, is joined by branches from the left pneumogastric and right phrenic nerves, and it distributes filaments to the right supra-renal plexus; the *splenic plexus* is formed by branches from the left semilunar ganglion and the right pneumogastric nerve.

The *supra-renal plexus* is formed by branches from the solar plexus, the semilunar ganglion, and the diaphragmatic plexus, and is larger on the right than on the left side.

The *renal plexus* consists of numerous filaments from the semilunar ganglion, and from the solar and aortic plexuses; it is also reinforced by branches from the splanchnic nerves. From this plexus is given off —

The *spermatic plexus*, which likewise receives filaments lower down from the aortic plexus; in the female it takes the name of the *ovarian plexus*.

The *superior mesenteric plexus* receives, in addition to its branches from the solar plexus, some filaments from the right pneumogastric nerve and the cœliac plexus. It is the densest of all the plexuses derived from the solar plexus, and it breaks up into secondary plexuses corresponding to the branches of the artery of the same name.

The *inferior mesenteric plexus* comes mainly from the left side of the aortic plexus.

Hypogastric Plexus. — The *hypogastric plexus* is situated between the common iliac arteries on the last lumbar vertebra and the sacrum. It consists of an intricate interlacement of sympathetic filaments, which pass down into the pelvis, for the supply of the pelvic viscera. Although this plexus is so intricate it presents no distinct ganglia. As it passes down it receives branches from some of the spinal nerves, but mainly

from the third and fourth sacral nerves. From this large plexus are derived secondary plexuses, which ramify around branches of the internal iliac artery: thus there are, the inferior hæmorrhoidal plexus, the vesical, the uterine, the ovarian, the prostatic, and the vaginal; all of which send filaments which accompany the smallest branches of the arteries.

Lumbar Plexus of Nerves. — The *lumbar plexus* is formed by the union of the anterior branches of the four upper lumbar nerves, and is frequently connected with the last dorsal nerve by a small loop — the dorsi-lumbar nerve. The fifth does not enter into the formation of this plexus, but joins the sacral plexus under the name of the lumbo-sacral cord. The plexus lies over the transverse processes of the corresponding vertebræ, embedded in the substance of the psoas, so that this muscle must be dissected away before the plexus can be seen. Like the brachial plexus, the nerves composing it successively increase in size from above. Its branches are five in number, and arise in the following order (Fig. 177).

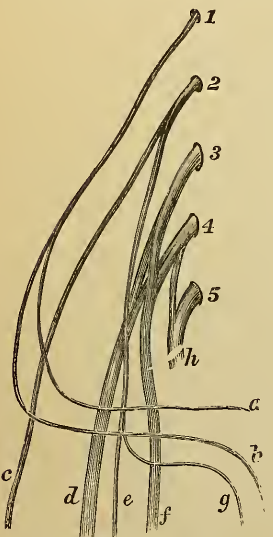


FIG. 177. — PLAN OF THE LUMBAR PLEXUS AND BRANCHES.

a. Ilio-hypogastric n. *b.* Ilio-inguinal n. *c.* External cutaneous n. *d.* Anterior crural n. *e.* Crural branch of genito-crural n. *f.* Obturator n. *g.* Genital branch of genito-crural n. *h.* Lumbo-sacral n. 1. First lumbar n. 2. Second lumbar n. 3. Third lumbar n. 4. Fourth lumbar n. 5. Fifth lumbar n.

a. The *first lumbar nerve* generally divides into two branches, the upper being the ilio-hypogastric, the lower the ilio-inguinal. They pass downwards and outwards nearly parallel with each other, cross obliquely over the quadratus lumborum to the crest of the ilium, and then separate.

The *ilio-hypogastric nerve* emerges from the outer border of the psoas, and crossing the quadratus lumborum, passes forwards to the crest of the ilium, where it pierces the transversalis and divides into its two terminal branches — the *iliac* branch, which pierces the internal and external oblique muscles and supplies the skin over the gluteal region, behind the last thoracic nerve; and the *hypogastric* branch, which runs forwards between the transversalis and internal oblique, and then perforates the aponeurosis of the external oblique to supply the skin of the hypogastric region.

The *ilio-inguinal nerve* — the smaller — comes through the psoas and perforates the transversalis close to the front of the iliac crest, where it communicates with the preceding nerve. It then pierces the internal oblique, and lying in front of the spermatic cord, comes out through the external abdominal ring and supplies

the skin of the inner and upper part of the thigh, of the penis and scrotum in the male, and of the labium in the female.

The *genito-crural nerve* is small, and comes from the second lumbar, and by a few filaments from the communicating branch of the first. After perforating the psoas, it lies for a short distance upon its anterior surface, and then runs down along the outer side of the external iliac artery. Near the crural arch it divides into the *genital* branch (*g*), which runs down on the external iliac artery, and, piercing the fascia transversalis, descends through the internal abdominal ring, along the inguinal canal, on the posterior aspect of the spermatic cord; it supplies the cremaster in the male, and the round ligament in the female; and the *crural* branch (*e*), which proceeds under the crural arch, enters the sheath of the femoral vessels, and, piercing the anterior layer of the sheath, just external to the artery, is lost in the skin of the upper part of the front of the thigh; here it communicates with the middle cutaneous nerve and supplies also a few filaments to the femoral artery, where it perforates the sheath of that vessel.

The *external cutaneous nerve of the thigh* (*c*) is generally derived from the loop between the second and third lumbar nerves. It runs through the psoas, then, crossing obliquely over the iliacus towards the anterior superior spine of the ilium, passes beneath the crural arch, and is finally distributed to the skin on the outside of the thigh. If the external cutaneous be not found in its usual situation, look for it as a distinct branch of the anterior crural, nearer the psoas muscle.

The *anterior crural* (*d*), the largest and most important branch, is formed by the union of the third and fourth lumbar nerves, receiving a small branch from the second. It descends in a groove between the psoas and the iliacus behind the fascia iliaca, supplies both these muscles and a branch to the femoral artery, and then, passing under the crural arch to the outer side of the femoral artery, is finally distributed to the extensor muscles of the knee, to the sartorius and pectineus, and the skin of the thigh and leg.

The *obturator nerve* (*f*), next in size to the anterior crural, proceeds from the third and fourth lumbar nerves, and sometimes from the second. It descends through the psoas muscle, and then, getting to its inner border, runs along the brim of the pelvis above its corresponding vessels to the obturator foramen, through the upper part of which it passes to the adductor muscles of the thigh.

The *accessory obturator nerve*, by no means a constant branch, is derived from the third and fourth lumbar nerves, and sometimes from the obturator nerve. It runs down along the inner border of the psoas, passes in front of the horizontal ramus of the os pubis, supplies the pectineus, and gives off a small branch to the hip-joint, and another to communicate with the anterior branch of the obturator nerve.

Postponing the minute anatomy of the abdominal viscera, begin the examination of the contents of the pelvis.

DISSECTION OF THE PELVIC VISCERA.

The functions of the pelvis are to protect its own viscera; to support those of the abdomen; to give attachment to the muscles which steady the trunk; to transmit the weight of the trunk to the lower limbs, and to give origin to the muscles which move them. In adaptation to these functions, the form of the pelvis is that of an arch, with broadly expanded wings at the sides, and projections in appropriate situations to increase the leverage of the muscles. The sacrum, impacted between the ilia, represents the keystone of the arch, and is

capable of supporting not only the trunk, but great burdens besides. The sides or pillars are represented by the ilia; these transmit the weight to the heads of the thigh-bones, and are thickest and strongest just in that line, *i.e.*, the brim of the pelvis, along which the weight is transmitted. Moreover, to effect the direct transmission of the weight, the plane of the arch is oblique. This obliquity of the pelvis, its hollow expanded sides, its great width, the position and strength of the tuberosities of the ischia, are so many proofs that man is adapted to the erect posture.

The general conformation of the pelvis in the female is modified, so as to be adapted to utero-gestation and parturition. Its breadth and capacity are greater than in the male. Its depth is less. The alæ of the iliac bones are more expanded. The projection of the sacrum is less perceptible, and consequently the brim is more circular. The depth of the symphysis pubis is less, the span of the pubic arch is wider. The bones, too, are thinner, and the muscular impressions less strongly marked.

The cavity of the pelvis being curved, the axis, or a central line drawn through it, must be curved in proportion. For all practical purposes, it is sufficient to remember that the axis of the pelvis corresponds with a line drawn from the anus to the umbilicus.*

Contents of the Male Pelvis. — The male pelvis contains the last part of the intestinal canal (named the rectum), the bladder with the prostate gland at its neck, and the vesiculæ

* In a well-formed female the base of the sacrum is $3\frac{3}{4}$ inches higher than the upper part of the symphysis pubis, and the point of the coccyx is rather more than half an inch higher than the lower part of the symphysis. The obliquity of the pelvis is greatest in early life. In the fœtus, and in young children, its capacity is small, and the viscera, which subsequently belong to it, are situated in the abdomen.

The relative diameters of the male and the female true pelvis are as follows:—

	Male.			Female.		
	Brim.	Cavity.	Outlet.	Brim.	Cavity.	Outlet.
	In. Cm.	In. Cm.	In. Cm.	In. Cm.	In. Cm.	In. Cm.
Transverse . .	$4\frac{1}{2}$ (11.3)	$4\frac{1}{2}$ (11.3)	$3\frac{1}{2}$ (8.8)	$5\frac{1}{4}$ (13.1)	5 (12.5)	$4\frac{3}{4}$ (11.8)
Oblique . . .	$4\frac{1}{4}$ (10.6)	$4\frac{1}{2}$ (11.3)	4 (10.0)	5 (12.5)	$5\frac{1}{4}$ (13.1)	$4\frac{3}{4}$ (11.8)
Antero-posterior	4 (10.0)	$4\frac{1}{2}$ (11.3)	$3\frac{1}{4}$ (8.1)	$4\frac{1}{2}$ (11.3)	$5\frac{1}{4}$ (13.1)	5 (12.5)

seminales. If the bladder be empty, some of the small intestine will be in the pelvis ; not so if the bladder be distended.

The relative positions of these pelvic viscera are as follows : most posteriorly is the rectum, which follows the curve of the sacrum and coccyx, and ends at the anus ; immediately in front is the oval hollow viscus, the bladder, which alters in size and position according to the amount of urine it contains ; in front of the bladder, surrounding its neck, and behind the os pubis, is the prostate gland. Placed beneath the bladder are the vesiculæ seminales, and curving round the sides of the bladder are the vasa deferentia, which subsequently lie beneath the base of the bladder. Passing downwards and inwards over the brim of the pelvis are the ureters, which likewise get beneath the fundus vesicæ. The bladder and the rectum are partially invested with peritoneum. Besides the pelvic viscera just enumerated, there are found, to the outer part of the pelvic cavity, the internal iliac artery and its branches, and the sacral plexus of nerves, with the obturator nerve running forwards to the obturator foramen. All the pelvic viscera are more or less invested by prolongations from the pelvic fascia, which constitute some of the true ligaments of the bladder ; also a capsule for the prostate, and coverings for the pelvic muscles. The superior hæmorrhoidal artery, the continuation of the inferior mesenteric, passes down into the pelvis, and supplies the upper half of the rectum. Some of these structures will now be described, while others can be better dissected in the side view of the pelvis.

Course of the Rectum. — The rectum enters the pelvis on the left side of the sacrum, and, after describing a curve corresponding with the concavity of the sacrum, terminates at the anus. In the first part of its course it is loosely connected to the back of the pelvis by a peritoneal fold, called the *meso-rectum:* between the layers of this fold, the superior hæmorrhoidal vessels, the continuation of the inferior mesenteric, with nerves and lymphatics, run to the bowel.

The rectum does not take this course in all cases ; sometimes it makes one, or even two lateral curves. In some rare cases it enters the pelvis on the right side instead of the left. Since these variations from the usual arrangement cannot be ascertained during life, they should make us cautious in the introduction of bougies.*

* In old age the rectum has sometimes a zigzag appearance immediately above the anus. These lateral inclinations are probably produced by the enormous distensions to which the bowel has been occasionally subjected.

Recto-vesical Pouch. — Whilst the parts are still undisturbed, introduce the finger into the *recto-vesical peritoneal pouch* (Fig. 178). This is a cul-de-sac formed by the peritoneum in passing from the front of the rectum to the lower and back part of the bladder. In the adult male, the bottom of this pouch is about one inch (*2.5 cm.*) distant from the base of the prostate gland; * therefore part of the under surface of the bladder is not covered by peritoneum; and since this part is in immediate contact with the rectum, it is practicable to tap the distended bladder through the front of the bowel without injur-

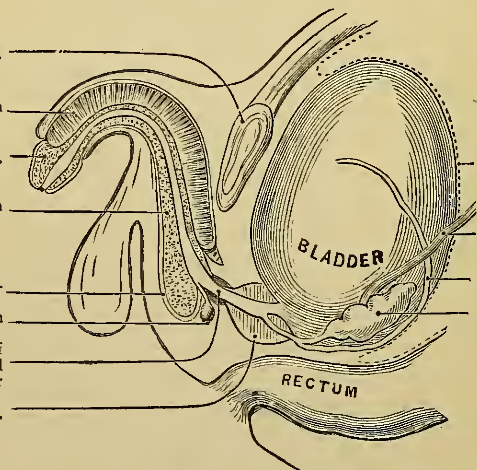


Fig. 178.—Diagram of the Relative Position of the Pelvic Viscera.

ing the peritoneum. It sometimes happens that the peritoneal pouch comes down nearer to the prostate than usual — we have seen it in actual contact with the gland; so that, in such a case, it would be impossible to tap the bladder from the rectum without going through the peritoneum. In children the peritoneum comes down lower than it does in the adult, because the bladder in the child is not a pelvic viscus.

The recto-vesical pouch is permanent. But there is another peritoneal pouch on the front part of the bladder, which is only produced when the bladder is distended. To produce it, the bladder should be blown up through one of the ureters. The

* The bottom of the pouch is from three to four inches (*7.5 to 10 cm.*) distant from the anus.

bladder soon fills the pelvis, and then, rising into the abdomen, occasions the pouch between it and the abdominal wall. At first the pouch is shallow, but it gradually deepens as the bladder rises. If the bladder be distended half-way up to the umbilicus, which is commonly the case when it has to be tapped, we find that the bottom of the pouch would be about two inches (*5 cm.*) from the symphysis pubis (Fig. 178). Within this distance from the symphysis, the bladder may be tapped in the linea alba, without risk of wounding the peritoneum. Thus, the surgeon has the choice of two situations in which he may tap the bladder — above the os pubis, or from the rectum. Which of the two be more appropriate, must be decided by the circumstances of the case.

False Ligaments of the Bladder. — The reflections of the peritoneum from the pelvic walls to the bladder constitute the *false ligaments of the bladder*, and they can be best examined before the viscera are disturbed, although they will be described when the bladder itself is dissected.

The *two posterior* pass forwards from the sides of the rectum to the back of the bladder, forming the lateral boundaries of the deep recto-vesical pouch. Each contains within its duplicature the obliterated hypogastric artery, the ureter, together with some vessels and nerves.

The *two lateral* pass inwards from the sides of the pelvis to the sides of the bladder.

The *superior* passes upwards from the summit of the bladder to the back of the anterior abdominal wall, covering the urachus and the obliterated hypogastric arteries.

Contents of the Female Pelvis. — The relative positions of the pelvic viscera in the female should now be examined, leaving the special description till a later stage.

General Position of the Uterus and its Appendages. — The uterus is interposed between the bladder in front and the rectum behind. From each side of it a broad fold of peritoneum extends transversely to the side of the pelvis, dividing that cavity into an anterior and a posterior part. These folds are called the *broad ligaments* of the uterus. On the posterior surface of the ligament are the ovaries, one on each side. They are completely covered by peritoneum, and suspended to the ligament by a small peritoneal fold. Each ovary is attached to the uterus by a cord termed the *ligament of the ovary.* Along the upper part of the broad ligament we find

between its layers a tube about four inches (*10 cm.*) long, called the *Fallopian tube*, which conveys the ovum from the ovary into the uterus. For this purpose one end of it terminates in the uterus, while that nearer to the ovary expands into a wide mouth, furnished with prehensile fringes — *fimbriæ* — which, like so many tentacles, grasp the ovum as soon as it escapes from the ovary. One of these fimbriæ is attached to the ovary. Lastly, there run up to the ovary, between the layers of the broad ligament, the ovarian vessels, which arise from the

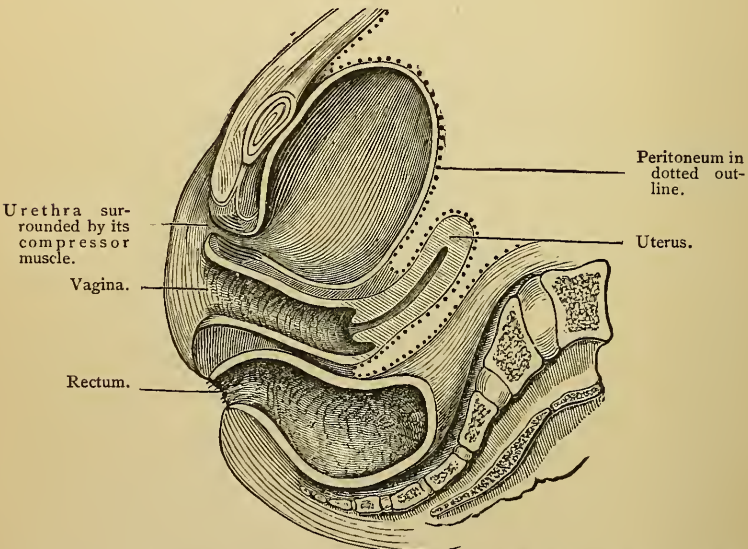


FIG. 179. — DIAGRAMMATIC VERTICAL SECTION THROUGH THE FEMALE PELVIC VISCERA.

aorta in the lumbar region, like the spermatic arteries in the male, because the ovaries are originally formed in the loins.

On the anterior surface of the broad ligament, on either side between its layers, is the *round ligament* of the uterus. This cord proceeds from the fundus of the uterus, anterior to the Fallopian tube, through the inguinal canal, like the spermatic cord in the male, and terminates in the mons Veneris. Besides one or two small blood-vessels, it contains muscular fibres analogous to those of the uterus; these increase very much in pregnancy, so that, about the full term, the cord becomes nearly as thick as the end of the little finger. In early life the round

ligament receives a covering from the peritoneum, which advances to a tubular form into the inguinal canal. It corresponds to the processus vaginalis of the peritoneum in the male. It is called the *canal of Nück*, and is generally obliterated in the adult. It is sometimes the seat of an inguinal hernia.

Reflections of the Peritoneum. — From the front of the rectum the peritoneum is reflected on to a small part of the posterior wall of the vagina, thus forming what is called the *recto-vaginal pouch*. From the vagina the peritoneum is continued over the posterior surface, but only about half way down the *front* of the uterus; thence it is reflected over the posterior surface of the bladder, on to the wall of the abdomen. Laterally, it is reflected from the uterus to the sides of the pelvis, forming the *broad ligaments*.

In cases of ascites the fluid might distend the recto-vaginal pouch, and bulge into the vagina, so that it would be practicable to draw it off through this channel.

DISSECTION OF THE MALE PERINEUM.

Before dissecting the perineum, it is expedient first to examine the osseous and ligamentous boundaries of the lower aperture of the pelvis. Looking at the male pelvis (with the ligaments preserved), we observe that this aperture is of a lozenge shape; that it is bounded *in front* by the pubic arch and the sub-pubic ligament; *laterally*, anteriorly, by the rami of the os pubis and ischium, and the tuberosity of the ischium, posteriorly, by the great sciatic ligament; and *behind*, by the tip of the coccyx.

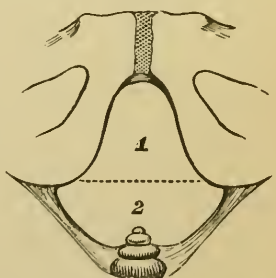


Fig. 180.—Diagram of the Framework of the Perineum.

This space, for convenience of description, is subdivided into two by a line drawn from one tuber ischii to the other. The anterior forms a nearly equilateral triangle, of which the sides are from three to three and a half (*7.5 to 8.8 cm.*) inches long; and, since it transmits the urethra, it is called the *urethral region* of the perineum. The posterior, containing the anus, is called the *ischio-rectal* or *anal region* (Fig. 180).*

* The dimensions of the lower outlet of the pelvis are apt to vary in different subjects, and the lithotomist must modify his incision accordingly.

The subject should be placed in the usual position for lithotomy, with a block placed beneath the pelvis. A full-sized staff should now be passed into the bladder, the rectum moderately distended with tow, and the scrotum raised by means of hooks. A central ridge, named the *raphé*, extends from the anus, along the perineum, scrotum, and under surface of the penis. Between the tuberosities of the ischia and the anus are two depressions, one on each side, marking the *ischio-rectal fossæ*, which are found immediately beneath the skin, filled with more or less fat. In the lateral operation of lithotomy, the incision should commence at a point midway between the anus and the posterior fold of the scrotum, close to the left side of the raphé ; it should be carried downwards and outwards to a point midway between the tuber ischii and the anus. In the bilateral operation, the incision is semilunar, the horns being made on either side between the tuber ischii and the anus, equidistant from these points respectively ; while the centre of the incision runs about three-quarters of an inch (*18 mm.*) above the anus.

Anal Glands.—At the anus the skin becomes finer and more delicate, forming a gradual transition towards mucous membrane : during life it is drawn into wrinkles by the permanent contraction of the cutaneous sphincter. Moreover, the skin at the margin of the anus is provided with numerous minute glands,* which secrete an unctuous substance to facilitate the passage of the fæces. When this secretion becomes defective or vitiated, the anal cutaneous folds are apt to become excoriated, chapped, or fissured ; and then defæcation becomes very painful. At the margin of the anus a thin white line can be distinguished, indicating, not only the junction of the skin with the mucous membrane, but also the linear interval between the external and internal sphincters.

Dissection.—The skin should be reflected by making an incision along the raphé, round the margin of the anus to the coccyx. Two others must be made on each side at right angles to the first, the one at the upper, and the other at the lower end of it.

Subcutaneous Tissue.—The skin of the perineum must then be reflected outwards with much care, otherwise the super-

* These glands are the analogues of the anal glands in some animals, e.g., the dog and the beaver. They are found not only about the anus, but also in the subcutaneous tissue of the perineum, a fact for the demonstration of which we are indebted to the late Professor Quekett. They are large enough to be seen with the naked eye.

ficial sphincter ani may be reflected with the skin. In reflecting the skin notice the characters of the subcutaneous structures.* Its characters alter in adaptation to the exigencies of each part. On the scrotum the fat constituent of the tissue is entirely absent; while the connective tissue element is most abundant, and during life elastic and contractile.

Fat in Ischio-rectal Fossæ.— But, towards the deeper part of the anus the fat accumulates more and more, and on either side of the rectum it is found in the shape of large masses, filling up what would otherwise be two deep hollows in this situation — namely the *ischio-rectal fossæ.* These fossæ are pyramidal, with their bases towards the skin, and their apices at the divergence of the obturator internus and levator ani. They are about two inches (*5 cm.*) in depth, and much deeper posteriorly than in front. This accumulation of fat on each side of the anus permits the easy distention and contraction of the lower end of the bowel during and after the passage of the fæces. Over the tuberosities of the ischia are large masses of fat, separated by tough, fibrous septa, passing from the skin to the bone, so as to make an elastic padding to sit upon. Occasionally, too, there are one or more large *bursæ* interposed between this padding and the bone.

So much respecting the general characters of the subcutaneous tissue of the perineum. Some anatomists describe it as consisting of three, four, or even more layers, but in nature we do not find it so. It may, indeed, be divided into as many layers as we please, according to our skill in dissection; but this only complicates what is, in itself, simple.

Dissection. — The external sphincter ani must now be cleaned, care being taken not to remove any of its fibres, which are intimately connected with the skin. Posteriorly, the lower border of the gluteus maximus must be displayed, and the vessels and nerves crossing the perineum, towards the anus, carefully dissected.†

External Sphincter Ani. — The *external sphincter* of the anus is elliptical, and is composed of a thin layer of striped

* The probable thickness of this subcutaneous tissue is a point which ought to be determined by the lithotomist in making his first incision. Its great thickness in some cases explains the depth to which the surgeon has to cut in letting out pus from the ischio rectal fossa.

† Radiating outwards from the margin of the anus is a thin stratum of involuntary muscular fibres, called the *corrugator cutis ani*, which by its action produces the radiating ridges of skin from the anus.

muscular tissue about an inch (*2.5 cm.*) in breadth. It *arises* from the tip of the coccyx and the ano-coccygeal ligament. The muscular fibres surround the anus, and are *inserted* in a pointed manner in the tendinous centre of the perineum, in conjunction with the transversus perinei, the accelerator urinæ, and the levator ani (Fig. 181, p. 499). It is called the external sphincter, to distinguish it from a deeper and more powerful band of muscular fibres which surrounds the last inch or more of the rectum, and is situated next to the mucous membrane.

Cutaneous Vessels and Nerves. — The cutaneous vessels and nerves of the perineum come from the internal pudic artery and nerve, and chiefly from that branch of it called the *superficialis perinei.* This will be traced presently.

The *external* or *inferior hæmorrhoidal arteries* cross transversely through the ischio-rectal fossa, from the ramus of the ischium towards the anus. They come from the pudic (which can be felt on the inner side of the ischium), and, running inwards, divide into numerous branches, which supply the rectum, levator ani, and sphincter ani. The *nerves* which accompany the arteries come from the pudic nerve, and supply the sphincter ani and the skin of the perineum.

The *fourth sacral nerve* emerges through the coccygeus close to the tip of the coccyx, and, through its *hæmorrhoidal* or *perineal branch*, supplies the external sphincter and the skin of the perineum between the coccyx and the anus.

The *inferior pudendal nerve* comes through the muscular fascia of the thigh, a little above the tuber ischii, and ascends, dividing into filaments, which supply the front and outer part of the scrotum and perineum. It is a branch of the lesser sciatic nerve, and communicates in front with the posterior branch of the superficial perineal nerve.

Superficial Fascia of the Perineum. — The subcutaneous fascia of the perineum is composed of a *superficial* and a *deep* layer. The *superficial* layer contains more or less fat, and is continuous with that of the scrotum, the thighs, and the posterior part of the perineum. The *deeper* layer is a stratum of considerable strength, and is best demonstrated by blowing air beneath it with a blow-pipe; its connections are as follows: It is attached on each side to the anterior lip of the ramus of the os pubis and ischium superficial to the crus penis; traced forwards, it is directly continuous with the *tunica dartos* of the scrotum; traced backwards, at the base of the urethral triangle, it is reflected beneath the transversus perinei muscle, and joins the *deep perineal fascia* or *triangular ligament.* These connections explain why urine effused into the perineum does not make its way into the ischio-rectal fossæ or down the thighs, but passes readily forwards into the connective tissue of the scrotum, penis, and groins.

Dissection. — Remove the fascia to see the muscles which cover the bulb of the urethra and the crura of the penis. The

bulb of the urethra lies in the middle of the perineum, and is covered by a strong muscle, called accelerator urinæ. The cruræ penis are attached, one to each side of the pubic arch, and are covered each by a muscle, called erector penis. A narrow slip of muscle, called transversus perinei, extends on either side from the tuber ischii to the *tendinous centre* of the

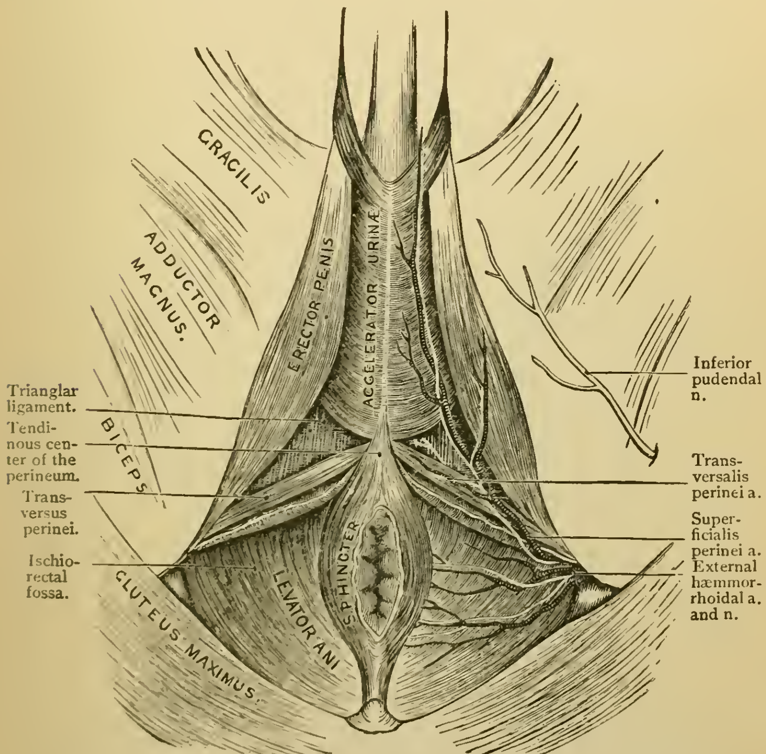


FIG. 181. — MUSCLES, WITH SUPERFICIAL VESSELS AND NERVES, OF THE PERINEUM.

perineum. This point is about one inch and a quarter (*3.1 cm.*) in front of the anus, and serves for the attachment of muscular fibres from all quarters of the perineum.

Thus the muscles of the perineum describe on each side a triangle, of which the sides are formed by the accelerator urinæ and the crus penis respectively, and the base by the transversus perinei. Across this triangle run up from base to apex the

superficial perineal vessels and nerves. External to the ramus of the ischium is seen the *inferior pudnedal* nerve, a branch of the lesser sciatic.

Superficial Perineal Vessels and Nerves. — The *superficial perineal* artery lies beneath the deep layer of the superficial perineal fascia, and comes from the internal pudic as it runs up the inner side of the tuber ischii. Though the main trunk cannot be seen, it can be easily felt by pressing the finger against the bone. The artery comes into view a little above the level of the anus, passes up usually in front of the transversus perinei muscle, and gets to the perineal triangle lying to the inner side of the erector penis. It distributes branches to all the muscles, and is finally lost on the scrotum.

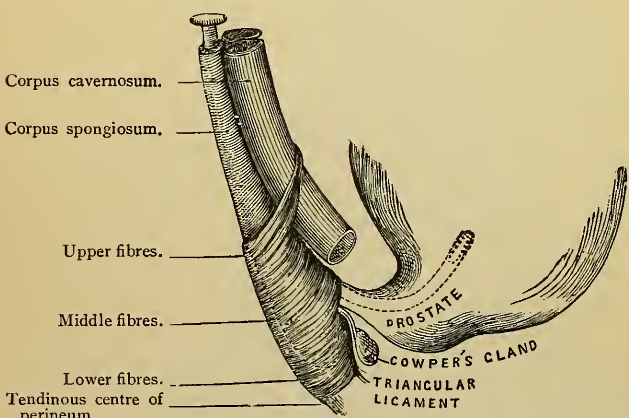


FIG. 182.—DIAGRAM TO SHOW THE ACCELERATOR URINÆ IN PROFILE.

The only named branch is called *transversalis perinei* (Fig. 181). This is given off near the base of the triangle, and runs transversely inwards with the transversus perinei muscle towards the central tendon of the perineum, where it anastomoses with its fellow. It is necessarily divided in the first incision in lithotomy, and deserves attention, because it is sometimes of considerable size.

The artery is accompanied by two *veins*, which are frequently dilated and tortuous, especially in diseased conditions of the scrotum.

The *nerves*, two in number, are derived from the internal pudic, follow the course of their corresponding arteries, and

give off similar branches. They not only supply the skin of the perineum and scrotum, but each of the perineal muscles.

Accelerator Urinæ. — This muscle embraces the bulb of the urethra, and is composed of two lateral symmetrical halves. It *arises* from a fibrous median raphé beneath the bulb, and from the tendinous centre of the perineum. Starting from this origin the fibres diverge, and are *inserted* as follows: The *upper* ones proceed on either side round the corpus cavernosum penis, like the branches of the letter V, and are fixed on its dorsal surface, in front of the erector penis, and expanding also into a broad aponeurosis, which covers the dorsal vessels of the penis; the *middle* completely embrace the bulb and adjacent part of the corpus spongiosum like a ring, and meet in an aponeurosis on the upper surface of the urethra; the *lower* are fixed to the anterior surface of the deep perineal fascia, often called the triangular ligament (Fig. 182).*

Thus, the entire muscle acts as a powerful compressor of the bulb, and expels the last drops of urine from this part of the urethra.† By dividing the muscle along the middle line and turning back each half, its insertion, as above described, can be clearly made out.

Erector Penis. — This muscle is moulded upon the crus of the penis. It *arises* by musculo-tendinous fibres from the inner surface of the tuber ischii, from the crus itself, and from the ramus of the os pubis; the fibres ascend, completely covering the crus, and terminate on a strong aponeurosis, which is *inserted* into the external and inferior aspect of the crus penis (Fig. 181). The *action* of this muscle is to compress the root of the penis, and so, by preventing the return of the venous blood, contributes to the erection of the organ.‡

Transversus Perinei. — This muscle is of insignificant size, and sometimes absent (Fig. 181). It *arises* from the inner aspect of the tuber ischii, and proceeds forwards and inwards towards the central point of the perineum, where it is blended with the muscle of the opposite side, with the fibres of the accelerator urinæ in front, and with the external sphincter behind. This muscle with its artery is divided in lithotomy.

* This muscle is called also the *ejaculator urinæ* or the *bulbo-cavernosus*.

† The middle fibres assist in the erection of the corpus spongiosum, and the upper fibres in that of the penis, the former by compressing the bulb, the latter by compressing the dorsal vein.

‡ This muscle is sometimes called the *ischio-cavernosus*.

The *deep transversus perinei* is a small muscle occasionally present; it arises more deeply from the pubic arch than the superficial muscle, and passes inwards behind the bulb to the central tendon.

The next stage of the dissection consists in reflecting and removing the accelerator urinæ from the bulb of the urethra,

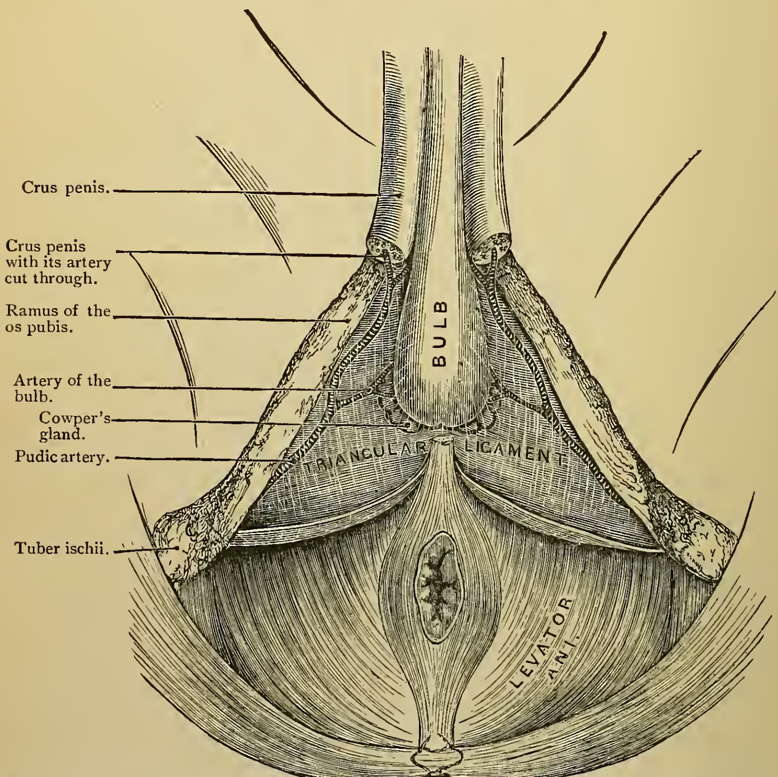


FIG. 183.—DIAGRAM TO SHOW THE TRIANGULAR LIGAMENT OF THE URETHRA OR DEEP PERINEAL FASCIA.

the erectores penis with the crura penis from the rami of the os pubis and ischium, and the transversi perinei muscles. This done, the *triangular ligament* or *deep perineal fascia* is fairly exposed.

Triangular Ligament of the Urethra. — Understand that the triangular ligament of the urethra and the deep perineal fascia are synonymous terms.

The *triangular ligament*, shown in Fig. 183, is a strong fibrous membrane stretched across the pubic arch. It is about an inch and a half (*3.8 cm.*) in depth, with the base directed backwards. It consists of two layers — an anterior and a posterior. The *anterior layer* is firmly attached on each side

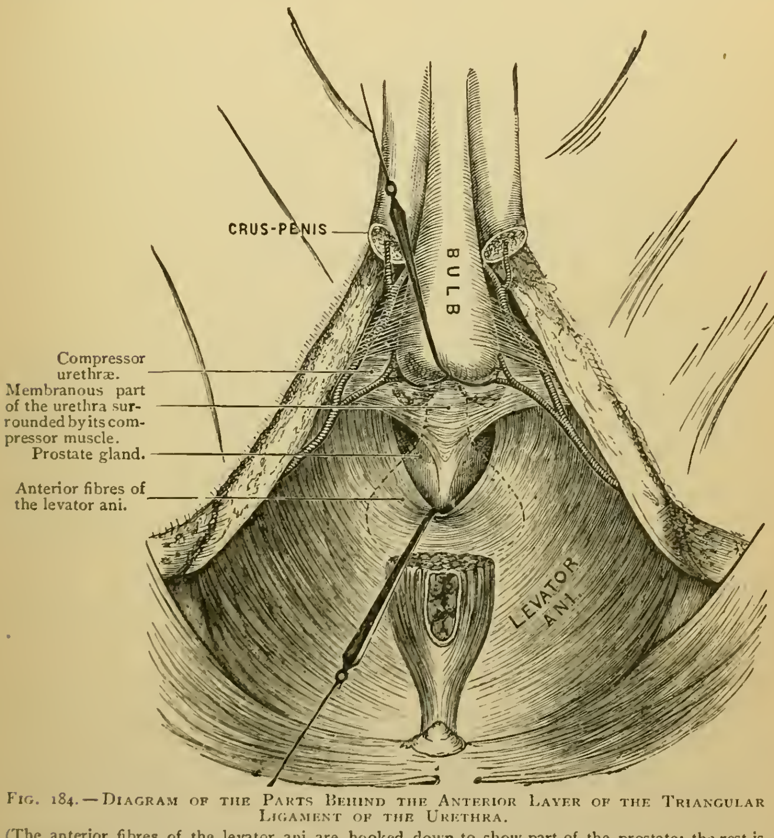


FIG. 184. — DIAGRAM OF THE PARTS BEHIND THE ANTERIOR LAYER OF THE TRIANGULAR LIGAMENT OF THE URETHRA.

(The anterior fibres of the levator ani are hooked down to show part of the prostate; the rest is tracked by a dotted line.)

to the *posterior* lip of the rami of the os pubis and ischium, beneath the crus penis; superiorly — *i.e.*, towards the symphysis of the os pubis — it is connected with the subpubic ligament; inferiorly, it does not present a free border, but is connected to the tendinous centre of the perineum, and is continuous with the deep layer of the superficial perineal fascia which curves

backwards under the transversus perinei muscle, and with the ischio-rectal or anal fascia (p. 498).

The anterior layer of the triangular ligament is perforated about one inch (*2.5 cm.*) below the symphysis pubis for the membranous part of the urethra. The aperture through which the urethra passes does not present a distinct edge, because the ligament is prolonged forwards over the bulb, and serves to keep it in position. It also presents apertures for the transmission of the dorsal vein, and outside this for the pudic arteries and nerves.

The *posterior layer* cannot at present be seen. It belongs, strictly speaking, to the obturator prolongation of the pelvic fascia, and slopes somewhat backwards from the anterior layer so as to leave an interval between them, in which are found structures which will be presently described.

Points of Surgical Interest. — The triangular ligament is very important surgically for these reasons : —

1. Here we meet with difficulty in introducing a catheter, unless we can hit off the right track through the ligament. The soft and spongy tissue of the bulbous part of the urethra in front of the ligament readily gives way if force be used, and a false passage results.

2. By elongating the penis, we are much more likely to hit off the proper opening through the ligament.

3. When, in retention of urine, the urethra gives way *anterior* to this ligament, it is this which prevents the urine from travelling into the pelvis. Its connection with the superficial perineal fascia prevents the urine from getting into the ischio-rectal fossæ : nor can the urine make its way into the thighs. The only outlet for it is into the connective tissue of the scrotum and penis.

4. When suppuration or extravasation of urine takes place *behind* the ligament, the pus is pent up and should be speedily let out ; if not, it may find its way into the connective tissue of the pelvis, and may burst into the urethra or the rectum.

5. The ligament is partially cut through in lithotomy.

Parts Divided in Lateral Lithotomy. — The parts divided in the lateral operation of lithotomy are : the skin, the superficial fascia, the transverse perineal muscle, vessels and nerve, the inferior hæmorrhoidal vessels and nerves, the inferior fibres of the acclerator urinæ, the anterior fibres of the levator ani, the triangular ligament (anterior layer), the compressor urethræ, the membranous and prostatic parts of the urethra, and a small portion of the prostate.

Parts to be Avoided. — The incision in lateral lithotomy should not be made too far forwards, for fear of wounding the artery of the bulb ; nor too far inwards, for fear of injuring the rectum ; nor too far outwards, for fear of cutting the pudic artery.

Structures Between the Layers of the Triangular Ligament. — The anterior layer of the triangular ligament must now be cut away to see what lies between its two layers. These parts are shown in Fig. 183, namely : 1, the membranous part of the urethra, surrounded by, 2, the compressor

urethræ muscle; 3, Cowper's glands and their ducts; 4, the pudic artery and its branch, the artery of the bulb; the artery of the crus and the dorsal artery of the penis being given off in front of the anterior layer; 5, the pudic nerve and its branches; 6, the dorsal vein of the penis; 7, the subpubic ligament.

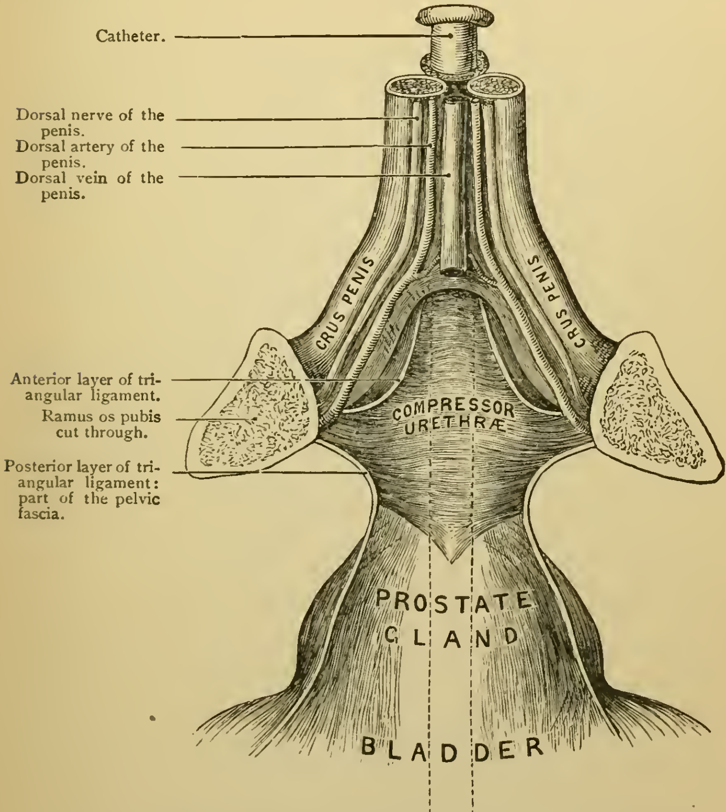


FIG. 185. — DIAGRAM OF THE RELATIONS OF THE COMPRESSOR URETHRÆ AS SEEN FROM ABOVE.

Dissection. — To obtain the best perineal view of the compressor urethræ muscle, cut through the spongy part of the urethra about three inches (*7.5 cm.*) above the end of the bulb, and dissect it from the corpus cavernosum. Thus, the upper fibres of the constrictor will be exposed; to see the lower, it is only necessary to raise the bulb. The most

perfect view, however, of the muscle is obtained by making a transverse section through the rami of the ossa pubis, so as to get at the muscle from above, as shown in Fig. 185.

Compressor or Constrictor Urethræ. — This muscle consists of transverse fibres which surround and support the whole length of the membranous portion of the urethra in its passage between the two layers of the triangular ligament. It *arises* from the ramus of the os pubis on either side for about half an inch (*13 mm.*); from thence its fibres pass, some above, some below the urethra, along the whole length of its membranous part. It forms a complete muscular covering for the urethra between the prostate and the bulb. It is chiefly through its agency that we retain the urine. This muscle is the chief cause of spasmodic stricture of the urethra. Besides this muscle, the membranous portion of the urethra is surrounded by involuntary circular muscular fibres, placed beneath the compressor urethræ and continuous with the muscular fibres of the bladder.

Cowper's Glands. — These small glands are situated, one on either side, immediately behind the bulb between the two layers of the triangular ligament, in the substance of the compressor urethræ. Their size is about that of a pea, but it varies in different individuals. They are compound racemose glands, consisting of several lobules firmly connected together by cellular and some muscular tissue. From each a slender duct runs forwards, and, after a course of about one inch, opens obliquely into the floor of the bulbous part of the urethra (Fig. 182). They furnish a secretion accessory to generation.

Pudic Artery and its Branches. — The *internal pudic artery* is a branch of the anterior division of the internal iliac. It leaves the pelvis through the great sciatic foramen between the pyriformis and coccygeus muscles, above the sciatic artery, winds round the spine of the ischium, re-enters the pelvis through the lesser sciatic foramen, and then runs along the inner side of the tuber ischii, between the layers of the obturator fascia, up towards the pubic arch. About an inch and a half (*3.8 cm.*) above the tuber ischii, the trunk of the pudic artery can be felt; but we cannot see it, nor draw it out, for it is securely lodged in a fibrous (Alcock's) canal formed by the obturator fascia. It subsequently pierces the posterior layer of the triangular ligament, runs along the inner margin of the ramus of the os pubis, and lastly, piercing the anterior layer of

the triangular ligament, it divides into the artery of the corpus cavernosum and the dorsal artery of the penis. In the present dissection we find the artery between the two layers of the triangular ligament, where it gives off the artery of the bulb of the urethra, and then pierces the triangular ligament (Fig. 183).

Taken in order, the branches of the pudic artery as seen in this dissection are: —

a. The *external hæmorrhoidal*, the *superficial perineal*, and the *transverse perineal* branches have already been described (p. 498).

b. The *artery of the bulb* is of considerable size, and passes transversely inwards between the two layers of the triangular ligament; it runs inwards through the substance of the compressor urethræ, and before it enters the bulb divides into two or three branches. It also sends downwards a small branch to Cowper's gland. From the direction of this artery it will at once strike the attention that there is great risk of dividing it in lithotomy. If the artery run along its usual level, and the incision be not made too high in the perineum, then indeed it is out of the way of harm. But, supposing the reverse, the vessel must be divided. This deviation from the normal distribution is met with about once in twenty subjects, and there is no possibility of ascertaining this anomaly beforehand.

c. The *artery of the corpus cavernosum*, one of the terminal branches, ascends for a short distance near the pubic arch, and soon enters the crus, running forwards in its cavernous structure by the side of the septum pectiniforme.

d. To see the *dorsal artery of the penis*, the crus should be dissected from its attachment to the symphysis pubis. The artery pierces the suspensory ligament, and can be traced upon the dorsum of the penis down to the glans. It forms a complete arterial circle with its fellow round the corona glandis, and gives numerous ramifications to the papillæ on the surface.

The *veins* corresponding with the branches of the pudic artery terminate in the pudic vein, with the exception of the *dorsal vein of the penis*. This vein is of large size and results from the union of two small veins in front on the dorsum of the penis which receive the blood from the glans, the corpus spongiosum, and the prepuce. The vein runs along the middle on the dorsum, pierces, first, the suspensory ligament, and then the triangular ligament under the symphysis, and divides into two branches which open into the prostatic plexus.

Pudic Nerve. — The *pudic nerve* comes from the lower part of the sacral plexus, and corresponds, both in its course and branches, with the artery.

It gives off, close to its origin, (*a*) the *external* or *inferior hæmorrhoidal*, which communicates in front with the superficial perineal and inferior pudendal nerves; (*b*) the *perineal*, which accompanies the superficial perineal artery, and divides into a posterior and an anterior branch; the former runs to the front of the ischio-rectal fossa, distributing branches to the sphincter and the skin in front of the anus; the latter lies in front of the preceding, and supplies the scrotum and under aspect of the penis; both communicate with each other and with the inferior pudendal nerve; (*c*) *muscular branches* to the transversus perinei, the accelerator urinæ, the erector penis, and the compressor urethræ; (*d*) the *dorsal nerve*, which is the

main trunk of the nerve, runs with the pudic artery, and with it pierces the posterior, and then the anterior layer of the triangular ligament; then perforating the suspensory ligament of the penis, it accompanies the dorsal artery on its outer side, along the dorsum of the penis to the glans. In its passage it supplies the integuments of the penis, and sends off one or two branches into the corpus cavernosum. This part of the penis also receives filaments from the sympathetic system.

Ischio-rectal Fossa. — This is the deep hollow, on each side, between the anus and the tuber ischii. When all the fat is removed from it, observe that it is lined on all sides by fascia. Introduce the finger into it to form a correct idea of its extent and boundaries. *Externally*, it is bounded by the tuber ischii and the fascia covering the obturator internus muscle; *internally*, by the rectum, levator ani, and coccygeus; *posteriorly*, by the gluteus maximus; *anteriorly*, by the transversus perinei. The fossa is crossed by the external hæmorrhoidal vessels and nerves.

These deep spaces on each side of the rectum explain the great size which abscesses in this situation may attain. The pus can be felt only through the rectum. Nothing can be seen outside. Perhaps nothing more than a little hardness can be felt by the side of the anus. These abscesses should be opened early, else they form a large cavity, and may burst into the rectum, and result in a fistula.

DISSECTION OF THE FEMALE PERINEUM.

The *pudenda* in the female consist of folds of the integument, called the labia. Between these is a longitudinal fissure which leads to the orifices of the urinary and genital canals.

Labia Majora. — The pubic region is generally surmounted by an accumulation of fat, called *mons Veneris*, which is covered with hair. From this, two thick folds of skin descend, one on either side, constituting the *labia majora*, and gradually diminish in thickness towards the perineum. Their junction, about an inch (*2.5 cm.*) above the anus, is called the *posterior commissure*, or *frænulum labiorum*, within which is a transverse crescentic fold, the *fourchette*: it is generally torn in the first labor. Between the fourchette and the posterior commissure is an oval depression, called the *fossa navicularis*. The inner layer of the skin of the labium is thinner, softer, and more like mucous membrane than the outer; for this reason, whenever pus forms in the labium, the abscess bursts on the inner side. Where the

labia are in contact, they are provided with small sebaceous glands, of which the minute ducts are observable on the surface. They are the analogues of the scrotum in the male, and occasionally contain extruded ovaries, forming a hernia of the ovary.

Clitoris. — In form and structure the clitoris resembles the penis on a diminutive scale, being about an inch and a half (*3.8 cm.*) long. It has, however, no corpus spongiosum or urethra. Like the penis, it is attached to the sides of the pubic arch by two crura (Fig. 186, p. 482), each of which is grasped by its special *erector clitoridis.* The crura are continued forward like the corpora cavernosa of the male, and unite to form the body of the organ, which is surmounted by a small *glans.* It has also, like the penis, a suspensory ligament. The glans is provided with extremely sensitive papillæ, and covered by a little prepuce. Its dorsal arteries and nerves are large in proportion to its size, and have precisely the same course and distribution as in the penis. Its internal structure consists of a plexus of blood-vessels, which freely communicate with those of the labia minora ; for one cannot be injected without the other.

Labia Minora or Nymphæ. — By separating the external labia, two small and thin folds of mucous membrane about an inch and a half (*3.8 cm.*) in length, are exposed, one on either side, termed *labia minora.* These folds converge anteriorly, and form a covering for the clitoris, called *preputium clitoridis ;* posteriorly, they are gradually lost on the inside of the labia majora. They, unlike the labia majora, do not contain fat, but are composed of minute veins. Between the nymphæ and about the clitoris are a number of sebaceous glands.

Between the labia minora, and below the clitoris, is an angular depression called the *vestibule,* at the back of which is the *meatus urinarius.* Immediately below this is the vagina, of which the orifice is partially closed in the virgin by a thin fold of mucous membrane called the *hymen.*

Hymen. — The *hymen* is a thin fold of mucous membrane which, in the virgin, extends across the lower part of the entrance of the vagina, about half an inch (*13 mm.*) behind the fourchette. In most instances its form is crescent-shaped, with the concavity upwards. There are several varieties of hymen: sometimes there are two folds, one on either side, so as to make the entrance of the vagina a mere vertical fissure : or there may be a septum perforated by several openings, *hymen cribriformis,* or by one only, *hymen circularis.* Again, there

may be no opening at all in it, and then it is called *hymen imperforatus*. Under this last condition no inconvenience arises until puberty. The menstrual discharge must then necessarily accumulate in the vagina: indeed, the uterus itself may become distended by it to such an extent as even to simulate pregnancy.

When the hymen is ruptured, it shrivels into a few irregular eminences, called *carunculæ myrtiformes*.

The presence of the hymen is not necessarily a proof of virginity, nor does its absence imply the loss of it. Cases are related by writers on midwifery in which a division of the hymen was requisite to facilitate parturition. In Meckel's Museum, at Halle, are preserved the external organs of a female in whom the hymen is perfect even after the birth of a seven-months' child.

Bartholin's or Duverney's Glands. — Between the orifice of the vagina and the erector clitoridis is imbedded in the loose tissue on either side a small gland, which corresponds to Cowper's gland in the male. Each is about half an inch (*13 mm.*) in length. Its long, slender duct runs forwards and opens on the inner side of the nympha external to the hymen. In cases of virulent gonorrhœa these glands are apt to become diseased, and give rise to the formation of an abscess in the labium very difficult to heal.

Urethra. — A smooth channel, called the *vestibule*, three-quarters of an inch (*18 mm.*) in length, leads from the clitoris down to the orifice of the urethra. This orifice, *meatus urinarius*, is not a perpendicular fissure like that of the penis, but rounded and puckered, and during life has a peculiar dimple-like feel, which assists us in finding it when we pass a catheter. You should practise the introduction of the catheter in the dead subject, for the operation is not so easy as might at first be imagined, provided the parts are not exposed. The point of the forefinger of the left hand should be placed at the entrance of the vagina, and the meatus felt for; when the catheter, guided by the finger, slips, after a little manœuvring, into the urethra.* The canal is about one inch and a half (*3.8 cm.*) in length, and runs along the upper wall of the vagina. The two canals are in such close apposition that you can feel

* In every case, and especially when any vaginal discharge exists, the parts should be exposed and cleansed in order to avoid septic infection of the bladder and kidney. The catheter must, of course, be made absolutely clean. (A. H.)

the urethra imbedded in the vagina like a thick cord. The urethra is slightly curved with the concavity upwards ; but for all practical purposes it may be considered straight. Its direction, however, is not horizontal. In the unimpregnated state it runs nearly in the direction of the axis of the outlet of the pelvis ; so that a probe pushed on in the course of the urethra would strike against the promontory of the sacrum. But, after impregnation, when the uterus begins to rise out of the pelvis, the bladder is more or less raised also in consequence of their mutual connection ; therefore, the urethra, in the latter months of utero-gestation, acquires a much more perpendicular course.

The female urethra is provided with a *compressor* muscle, similar, in origin and arrangement, to that which surrounds the membranous part of the urethra in the male. It also passes through the triangular ligament. The prostate gland is wanting, but there are minute glands scattered around the neck of the bladder. In consequence of the wider span of the pubic arch, and the more yielding nature of the surrounding structures, the female urethra is much more dilatable than the male. By means of a sponge-tent, it may be safely dilated to admit the easy passage of the fore-finger into the bladder. Advantage is taken of this great dilatability in the extraction of calculi from the bladder.

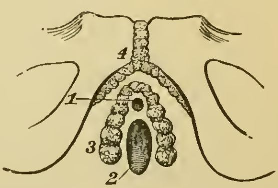


FIG. 186. — BULB OF THE VAGINA.*

1. Meatus urinarius. 2. Vagina. 3. Bulb of vagina. 4. Clitoris with its two crura.

The mucous coat of the urethra is pale and arranged in longitudinal folds, and is lined by squamous epithelium, which changes to the spheroidal variety near the bladder. Next to the mucous coat is a layer of elastic and non-striped muscular fibres intermixed. The muscular tissue is arranged in two layers — an outer, consisting of circular fibres, and an inner of longitudinal fibres. Externally there is a plexus of veins bearing a strong resemblance to erectile tissue.

Vagina. — The vagina is the canal which leads to the uterus ; at present, only the orifice of it can be seen. It is surrounded by a sphincter muscle, easily displayed by removing the integument. The muscle is about three-fourths of an inch (*18 mm.*) broad, and connected with the cutaneous sphincter of

* Taken from an injected preparation in the Musée Orfila, at Paris.

the anus in such a manner that they together form something like the figure 8.

On each side of the orifice of the vagina, between the mucous membrane and the sphincter, is a plexus of tortuous veins, termed the *bulb of the vagina,* from its analogy to the bulb of the urethra in the male. This vaginal bulb is about an inch (*2.5 cm.*) long, and extends across the middle line between the meatus urinarius and the clitoris, as shown in Fig. 186.

The description of the perineal branches of the pudic vessels and nerves, given in the dissection of the male perineum, applies, *mutatis mutandis,* to the female, excepting that they are proportionably small, and that the artery which supplies the bulb of the urethra in the male is distributed to the bulb of the vagina in the female.

ANATOMY OF THE SIDE VIEW OF THE PELVIC VISCERA.

Dissection. — To obtain a side view of the pelvic viscera, the left innominate bone should be removed thus: Detach the peritoneum and the levator ani from the left side of the pelvis, cut through the external iliac vessels, the obturator vessels and nerve, and the nerves of the lumbar plexus; then saw through the os pubis about two inches (*5 cm.*) external to the symphysis, and cut through the sacro-iliac symphysis; now draw the legs apart, and saw through the base of the spine of the ischium; after cutting through the pyriformis, the great sacro-sciatic ligament, the great and small sciatic nerves, and the gluteus maximus muscle, the innominate bone can be easily detached. This done, the rectum should be distended with tow, and the bladder blown up through the ureter. A staff should be passed through the urethra into the bladder, and a block placed under the sacrum.

The reflection of the peritoneum as it passes from the front of the rectum to the lower part of the bladder (forming the recto-vesical pouch), and thence over the back of the bladder to the wall of the abdomen, has been already described. You see where the distended bladder is bare of peritoneum, and that it can be tapped either through the rectum or above the pubes without injury to the serous membrane, as shown by the arrows in Fig. 187.

False Ligaments of the Bladder. — The peritoneal connections of the bladder are called its false ligaments; *false* in contradistinction to the *true*, which are formed by the fascia of the pelvis, and really *do* sustain the neck of the bladder in its proper position. The *false ligaments* are five in number, two posterior, two lateral, and one superior. The *posterior* are produced by two peritoneal folds, one on either side the recto-vesical pouch; the *two lateral*, by reflections of the peritoneum from the sides of the pelvis to the sides of the bladder; the

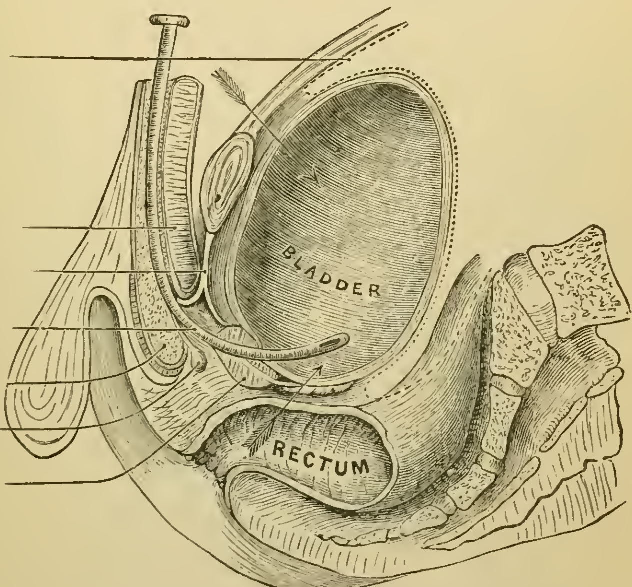


FIG. 187.—VERTICAL SECTION THROUGH THE PERINEUM AND PELVIC VISCERA.
(The arrows point out where the bladder can be tapped.)

superior is produced by the passage of the peritoneum from the front of the bladder to the abdominal wall. These have been already described (p. 493).

Pelvic Fascia. — To expose the *pelvic fascia*, the peritoneum must be removed from that side of the pelvis which has not been disturbed: in doing so notice the abundance of loose connective tissue interposed between the peritoneum and the fascia to allow the bladder to distend with facility. Whenever urine is extravasated into this loose tissue, it is sure to produce the

most serious consequences; therefore in all operations on the perineum it is of the utmost importance not to injure this fascia.

The pelvic fascia is a thin but strong membrane, and constitutes the true ligaments of the bladder and the other pelvic viscera, supporting and maintaining them in their proper position.

Examine, first, to what parts of the pelvis the fascia is attached; secondly, the manner in which it is reflected on the viscera.

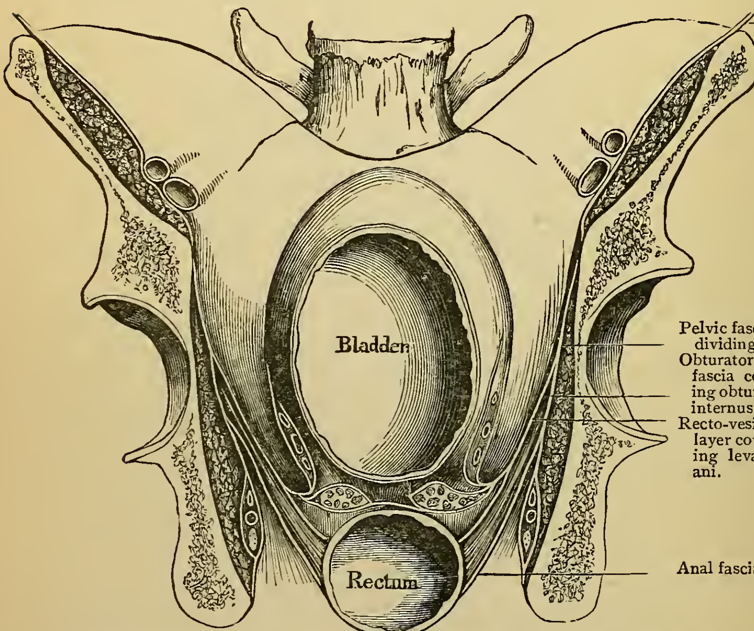


FIG. 188.—TRANSVERSE SECTION OF THE PELVIS, TO SHOW THE REFLECTIONS OF THE PELVIC FASCIA. (*After Gray.*)

Beginning, then (Fig. 188), we see that, in front, the fascia is continuous with the transversalis fascia, and laterally with the iliac fascia, and that superiorly it is attached to the body of the os pubis, to the brim of the pelvis, and to the side of the bone just above the attachment of the obturator internus, close to the obturator foramen and the great sciatic notch. Here it becomes gradually thinner, covers the pyriformis and the sacral plexus, and is gradually lost on the front of the sacrum.

Traced forwards, we find that it is attached to the bone along

the upper border of the obturator internus, and, as it passes forwards over the obturator foramen, completes the canal through which the obturator vessels pass to the foramen; anteriorly, it is attached to the posterior surface of the lower part of the symphysis pubis. From this attachment the fascia descends as far as a line drawn from the spine of the ischium to the pubic symphysis, where it forms a dense white line which marks the division of the fascia into two layers, an outer, the obturator, and an inner, the recto-vesical fascia. It also serves for the attachment of a considerable part of the middle portion of the levator ani.

The *obturator fascia*, the outer layer, is the continuation of the pelvic fascia, and descends on the inner surface of the obturator internus, forming at the same time a sheath for the pudic vessels and nerve, the nerve being the lowest. It is attached to the pubic arch, to the tuberosity of the ischium, and to the margin of the great sacro-sciatic ligament. It is continuous in front, below the symphysis pubis, with the corresponding layer of the opposite side, and here forms the posterior layer of the triangular ligament. From this fascia is derived the *ischio-rectal* or *anal fascia*, which lines the under or perineal surface of the levator ani, and is subsequently lost upon the side of the rectum.

The *recto-vesical fascia* descends on the upper or internal surface of the levator ani, and invests the bladder, prostate, and rectum. From the symphysis pubis it is reflected over the prostate and the neck of the bladder to form, on either side of the symphysis, two well-marked bands — the *anterior true ligaments* of the bladder. From the side of the pelvis it is reflected on to the side of the bladder, constituting the *lateral true ligaments* of that viscus, and encloses the prostate and the vesical plexus of veins. A prolongation from this ligament encloses the vesicular seminalis, the lower layer of which passes between the bladder and the rectum, to join its fellow from the opposite side. The continuation of the recto-vesical fascia covers the remainder of the upper surface of the levator ani as far as its attachment to the rectum, where it is reflected round this tube.

General Position of the Pelvic Viscera in the Male. — The pelvic viscera are so surrounded by veins and loose areolar tissue that he who dissects them for the first time will find a difficulty in discovering their definite boundaries. The rectum runs at the back of the pelvis, and follows the anterior curve of

the sacrum and coccyx. The bladder lies in front of the rectum, immediately behind the symphysis pubis. At the neck of the bladder is the prostate gland through which the urethra passes. In the cellular tissue, between the bladder and the rectum, there is, on each side, a convoluted tube, called the vesicula seminalis, and on the inner side of each vesicula is the seminal duct or vas deferens. Before describing these parts in detail, it is necessary to say a few words about the large tortuous veins which surround them.

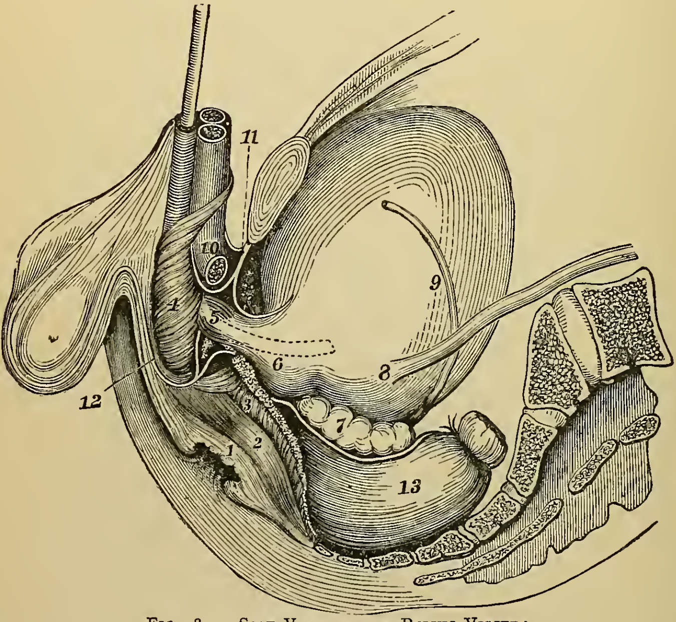


FIG. 189. — SIDE VIEW OF THE PELVIC VISCERA.
(Taken from a Photograph.)

1. External sphincter. 2. Internal sphincter. 3. Levator ani cut through. 4. Accelerator urinæ. 5. Membranous part of the urethra, surrounded by compressor muscle. 6. Prostate gland. 7. Vesicula seminalis. 8. Ureter. 9. Vas deferens. 10. Crus penis divided. 11. Triangular ligament. 12. Superficial perineal fascia. 13. Rectum.

Vesico-prostatic Plexus of Veins. — Beneath the pelvic fascia surrounding the prostate and the neck of the bladder are large and tortuous veins, which form the prostatic and the vesical plexuses. They empty themselves into the internal iliac. In early life they are not much developed, but as puberty approaches they gradually increase in size, and one not familiar with the anatomy of these parts would hardly credit the size which they sometimes attain in old persons. They communicate freely behind with the inferior hæmorrhoidal plexus, or veins about the anus, and they receive the blood returning from the penis through the large veins which pass under the pubic arch.

If, in lithotomy, the incision be carried beyond the limits of the prostate, the great veins around it must necessarily be divided; these, independently of any artery, are quite sufficient to occasion serious hæmorrhage.*

Rectum and its Relations.—The rectum is about eight inches (*20 cm.*) long. It is a continuation of the sigmoid flexure of the colon, enters the pelvis at the left sacro-iliac articulation, describes a curve corresponding to the sacrum and çoccyx, and terminates at the anus. The rectum also inclines from the left side to the middle line, and before its termination the bowel turns downwards, so that the anal aperture is dependent. Although it loses the sacculated appearance, it is not throughout of equal calibre, and its capacity becomes greater as it descends into the pelvis; immediately above the sphincter, it presents a considerable dilatation, the *ampulla* (Fig. 187). This dilatation is not material in early life, but it increases as age advances. Under such circumstances the rectum loses altogether its cylindrical form, and bulges up on either side of the prostate and the base of the bladder. For this reason the rectum should always be emptied before the operation of lithotomy.

The rectum is conveniently divided into three portions, the upper, the middle, and the lower.

The *upper portion* is about three inches and a half (*8.8 cm.*) in length, and extends as low as the third bone of the sacrum, to which bone it is connected by a fold of peritoneum, termed the *meso-rectum.* In this fold, the terminal branch of the inferior mesenteric artery with its vein runs down to supply the bowel. This portion of the rectum has behind it, the sacral plexus of nerves, the pyriformis, and some branches of the left internal iliac artery; in front, it has the bladder and the recto-vesical pouch.

The *middle portion* comprises three inches (*7.5 cm.*) in length, and is continuous with the lower portion at the tip of the coccyx. It is connected posteriorly to the sacrum and coccyx by loose connective tissue, and is covered by peritoneum only in front in the upper part, which forms the recto-vesical pouch. It has in front, the fundus of the bladder, the vesiculæ seminales, the vasa deferentia, and the prostate; while in the female it is closely connected to the posterior wall of the vagina.

* In the supra-pubic lithotomy it will be noted that the veins are enlarged, and great care should be taken to cut as few vessels as possible to avoid pelvic cellulitis, *i.e.*, separate tissues and vessels, until the bladder is reached. (A. H.)

The *lower portion* comprises the lowest inch and a half (*3.8 cm.*) of the rectum. It is entirely destitute of peritoneum, and is supported by the levatores ani, the larger portions of which are inserted into its side; it has also surrounding it, the internal, and lastly the external sphincters.* There is a considerable interval between it and the membranous portion of the urethra in the male, and the vagina in the female.

Digital Examination of the Rectum.—The relations of the front part of the rectum—that, namely, included between the recto-vesical pouch and the anus—are most important. If the forefinger be introduced into the anus, and a catheter into the urethra, the first thing felt through the front wall of the bowel is the membranous part of the urethra (Fig. 189). It lies just within the sphincter, and is about $\frac{4}{5}$ of an inch (*20 mm.*) in front of the gut. About one and a half or two inches (*3.8 to 5 cm.*) from the anus the finger comes upon the prostate gland; this is in close contact with the gut, and is readily felt on account of its hardness; by moving the finger from side to side we recognize its lateral lobes. Still higher up, the finger goes beyond the prostate, and reaches the trigone of the bladder: the facility with which this can be examined depends, not only upon the length of the finger and the amount of fat in the perineum, but upon the degree of distension of the bladder; the more distended the bladder, the better can the prostate be felt. These several relations are practically important. They explain why, with the finger in the rectum, we can ascertain whether the catheter is taking the right direction—whether the prostate be enlarged or not. We might even raise a stone from the bottom of the bladder so as to bring it in contact with the forceps.

The rectum is supplied with blood by the superior, middle, and inferior hæmorrhoidal arteries. The superior comes from the inferior mesenteric (p. 468); the middle from the anterior division of the internal iliac artery, and the inferior from the pudic artery. The superior hæmorrhoidal veins join the inferior mesenteric, and consequently the portal system; the middle and the inferior hæmorrhoidal veins join the internal pudic, and thence the internal iliac vein. They are very large and form loop-like plexuses about the lower part of the rectum. Having no valves, they are liable to become dilated and congested from various internal causes; hence the frequency of hæmorrhoidal affections.

* Some authors maintain that the rectum proper begins at the second portion above noted; but if the appearance of the muscular coat is to be taken, this description is the better of the two. The muscular coat is in two complete layers, longitudinal on the outside, and circular on the inside, starting at the left sacro-iliac joint. (A. H.)

Bladder.— This viscus, being a receptacle for the urine, must necessarily vary in size, and accordingly the nature of its connections and coats is such as to permit this variation. When contracted, the bladder sinks into the pelvis behind the pubic arch, and is completely protected from injury. But, as it gradually distends, it rises out of the pelvis into the abdomen, and, in cases of extreme distension, may reach up to the umbilicus.* Its outline can then be easily felt through the walls of the abdomen. The form † of the distended bladder is oval, and its long axis, if prolonged, would pass superiorly through the umbilicus, and inferiorly through the end of the coccyx. The axis of a child's bladder is more vertical than that of the adult; for in children the bladder is not a pelvic viscus. This makes lithotomy in them so much more difficult.

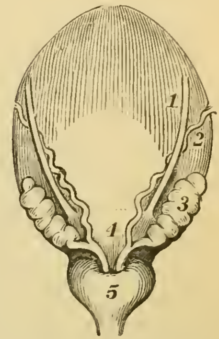


FIG. 190. — POSTERIOR VIEW OF THE BLADDER. 1. Ureter. 2. Vas deferens. 3. Vesicula seminalis. 4. Trigone. 5. Prostate.

The quantity of urine which the bladder will hold without much inconvenience varies. As a general rule, it may be stated at about a pint. Much depends upon the habits of the individual; but some persons have, naturally, a very small bladder, and are obliged to empty it more frequently.

In young persons the lowest part of the bladder is the neck, or that part which joins the prostate. But as age advances, the bottom of the bladder gradually deepens so as to form a pouch behind the prostate. In old subjects, particularly if the prostate be enlarged, this pouch becomes deep, micturition becomes tedious, and the bladder cannot completely empty its contents. It sometimes happens that a stone in the bladder is not felt;

* When the bladder is completely paralyzed it becomes like an inorganic sac, and there seems to be no limit to its distension. Hall found, in a drunkard, the bladder so dilated that it would hold twenty pints of water. (*Elem. Phys.* art. Vesica.) Frank saw a bladder so distended as to resemble ascites, and evacuated from it twelve pounds of urine. (*Oratio de Signis Morborum*, &c. &c. Ticini, 1788.)

W. Hunter, in his *Anatomy of the Gravid Uterus*, has given the representation of a bladder distended nearly as high as the ensiform cartilage.

† In all animals with a bladder, the younger the animal the more elongated is the bladder. This is indicative of its original derivation from a tube, *i.e.*, the *urachus*. In the infant, the bladder is of a pyriform shape, as it is, permanently, in the quadruped; but as we assume more and more the perpendicular attitude, the weight of the urine gradually makes the lower part more capacious.

the reason of which may be that the stone, lodged in such a pouch below the level of the neck of the bladder, escapes the detection of the sound. Under these circumstances, if the patient be placed on an inclined plane with the pelvis higher than the shoulders, the stone falls out of the pouch, and is easily struck.

The bladder is divided into a summit, a body, a base, and a neck.

The *summit* is its highest part, and to it is attached a thin fibrous cord, the urachus, which passes up to the umbilicus, and is the obliterated remains of a canal connecting the fœtal bladder with a sac external to the fœtus, called the allantois.

The *body* on its anterior aspect is not covered with peritoneum, and is in relation with the symphysis pubis, the triangular ligament, and the obturator internus; posteriorly, it is covered with peritoneum, and is in relation in the male with the rectum, and in the female with the uterus; laterally, it is only covered with peritoneum behind, and is in relation with the obliterated hypogastric arteries, the vasa deferentia, and ureters.

The *base* is the lowest part of the bladder resting upon the middle portion of the rectum, and is only slightly covered behind with peritoneum; below, it is in contact with the vesiculæ seminales and vasa deferentia, which latter pass forward as far as the prostate; the reflection of the peritoneum posteriorly with the vasa deferentia converging towards the front, forms a triangular space through which the bladder is tapped in cases of retention of urine.

The *neck* is the narrow portion where the urethra begins, and its direction is downwards and forwards. It is embraced by the prostate gland.

Ureter. — The *ureter* * is about twelve inches (*30 cm.*) long, and conveys the urine from the kidney to the bladder. In the dissection of the abdomen (p. 471), it was seen descending along the psoas muscle, behind the spermatic vessels, and crossing the common iliac artery into the pelvis. Tracing it downwards, in the posterior false ligament of the bladder, below the obliterated hypogastric artery, we find that it runs along the side of the bladder, external to the vas deferens, and enters it about an inch

* The length of the ureter is variously stated up to eighteen inches (*45 cm.*), but the length given above is the average. It is about $\frac{1}{6}$ of an inch (*4 mm.*) in diameter when distended, except about two inches (*5 cm.*) below the kidney, where it is slightly contracted. (A. H.)

and a half (*3.8 cm.*) behind the prostate, and about two inches (*5 cm.*) from its fellow of the opposite side (Fig. 188). It perforates the bladder very obliquely, so that the aperture, being valvular, allows the urine to flow into, but not out of it. The narrowest part of the ureter is at the vesical orifice ; here, therefore, a calculus is more likely to be arrested in its progress than at any other part of the canal.

Vas Deferens. — This tube, about sixteen inches (*40 cm.*) in length, one-twelfth of an inch (*2.5 mm.*) in diameter, conveys the seminal fluid from the testicle into the prostatic part of the urethra. Taking its origin at the lower part of the globus minor behind the testis, it ascends at the back part of the testis and epididymis, along the back of the spermatic cord through the inguinal canal into the abdomen ; then, leaving the cord at the inner ring, it curves round the deep epigastric artery, then crosses over the external iliac vessels, and descends into the pelvis on the side of the bladder, gradually approaching nearer the middle line. Before it reaches the prostate, it passes between the bladder and the ureter ; then becoming very sacculated, it runs forwards internal to the vesicula seminalis, and is joined by the duct of this vesicle. The common duct thus formed, *ductus communis ejaculatorius*, terminates in the lower part of the prostatic portion of the urethra (Fig. 178, p. 492). In point of size and hardness, the vas deferens has very much the feel of whipcord ; * its diameter in the funicular, inguinal, and pelvic portions as far as the post vesicular position is $\frac{1}{10}$ of an inch (*2.5 mm.*), the walls being very thick and calibre very small, about $\frac{1}{25}$ of an inch (*1 mm.*), and is composed of cellular, muscular, and mucous coats.

Vesiculæ Seminales. — These are situated, one on either side, between the base of the bladder and the rectum, and serve as reservoirs for the fluid secreted by the testes, and also secrete themselves a fluid accessory to that of the testicles (Fig. 189). Each is a tube, but so convoluted that it is like a little sacculated bladder. When rolled up, the tube is about two and a quarter inches (*6 cm.*) long, and a half an inch (*12.5 mm.*) in breadth ; unrolled, it would be more than twice that length, and about

* The description in the text assumes the bladder to be distended. But when the bladder is empty, the vas deferens runs down upon the side of the pelvis. In this course it may be seen, through the peritoneum, crossing — 1, the external iliac vessels ; 2, the remains of the umbilical artery ; 3, the obturator artery and nerve ; 4, the ureter.

the size of a small writing-quill. Its coats are the same as those of the vas deferens. Several cæcal prolongations proceed from the main tube, after the manner of a stag's horn. The vesiculæ seminales do not run parallel, but diverge from each other, posteriorly, as far as the reflection of the recto-vesical peritoneal pouch, like the branches of the letter V, and each lies immediately on the outer side of the vas deferens, into which it opens.

The vesiculæ seminales contain a brownish-colored fluid, presumed to be in some way accessory to the function of generation.*

Prostate Gland.—The prostate is a muscular and glandular mass situated at the neck of the bladder, and surrounds the first part of the urethra (Fig. 189). In the healthy adult it is about the size and shape of a horse-chestnut. Its *apex* is directed forwards as far as the deeper layer of the triangular ligament. It is surrounded by a plexus of veins (p. 516), and is maintained in its position by the pelvic fascia (p. 515). Its upper surface is about three-quarters of an inch (*18 mm.*) below the symphysis pubis; its apex is about one inch and a half (*3.8 cm.*) from the anus; the base is about two and a half (*6.3 cm.*). It consists of striped and unstriped muscular elements representing about half the entire mass. The unstriped fibres are found about the urethral orifices of the ejaculatory ducts, acting, probably, to prevent the backward flow of their contents, the striped fibres on the ventral aspect of the prostate completely encircling the apex of the organ, and are in contact with the transverse perinei muscle. Together both of these fibres assist the forward movement of the semen.

Above the prostate are the pubo-prostatic or anterior ligaments of the bladder, with the dorsal vein of the penis between them; *below*, and in contact with it, is the rectum; on *each side* of it is the levator ani; in *front* of it are the membranous part of the urethra (surrounded by its compressor muscle) and the triangular ligament; *behind*, are the neck of the bladder and the vesiculæ seminales with the ejaculatory ducts.

The transverse diameter is about one inch and a half (*3.8 cm.*); the vertical is about an inch (*2.5 cm.*). But the gland varies in size at different periods of life. In the child it is imperfectly

* The vesiculæ seminales are imperfectly developed till the age of puberty. In child three years of age they can hardly be inflated with the blowpipe.

developed: it gradually grows towards puberty, and generally increases in size with advancing age.

To ascertain the size and condition of the prostate during life, the bladder should be at least half full: the prostate is then pressed down towards the rectum, and readily within reach of the finger.

Anatomy of the Urethra in its Passage under the Pubic Arch. — The urethra is a musculo-mucous canal about eight inches (*20 cm.*) in length, and leads from the bladder to the end of the penis. It is divided into three portions — the *prostatic*, the *membranous*, and the *spongy*. At present only the relations of the *membranous part*, which comprises that part of the canal between the prostate and the bulb, can be examined. The urethra in this part is the narrowest of the canal, and measures one-half inch (*12.5 mm.*). In its passage under the pubic arch it is surrounded by the compressor urethræ (*Guthrie's muscle*), and below it are Cowper's glands. It tranverses the two layers of the triangular ligament, and is about an inch (*2.5 cm.*) below the symphysis pubis, from which it is separated by the dorsal vessels and nerves of the penis, and by some connective and muscular tissue; it is nearly the same distance above the rectum; it is not, however, equidistant from this portion of the intestine at all points, because of the downward bend which the rectum makes towards the anus.*

The membranous part of the urethra in children is very long, owing to the smallness of the prostate at that period of life; it is also composed of thin and delicate walls, and lies close to the rectum. In sounding a child, therefore, it is very necessary not to use violence, else the instrument is likely to pass through the coats of the urethra and make a false passage.

Levator Ani. — This muscle supports the anus and lower part of the rectum like a sling; and, with the coccygeus and compressor urethræ, forms a muscular floor for the cavity of the pelvis. To see the muscle, the pelvic fascia must be reflected from its upper surface. It *arises* in front, from the posterior aspect of the os pubis near the symphysis; behind, from the inner surface of the spine of the ischium; and, between these bones, from the tendinous line which marks the division of the pelvic fascia into the obturator and recto-vesical layers (Fig. 188,

* If a clean vertical section were made, we should see that the two canals form the sides of a triangular space, of which the apex is towards the prostate. This is sometimes called the recto-urethral triangle.

p. 514). From this long origin the fibres descend inwards towards the middle line, and are *inserted* thus : the anterior, the longest, passing under the prostate, meet their fellow in the middle line of the perineum in *front* of the anus (forming the *levator prostatæ*), joining the fibres of the transversus perinei and the external sphincter at the central tendon of the perineum ; the middle, the most numerous, are inserted into the side of the rectum ; the posterior are inserted, partly into the coccyx, and partly into the median raphé between the coccyx and the anus, and meet their fellow beneath the rectum.

The levator ani is supplied by the inferior hæmorrhoidal, the two lower sacral, and the coccygeal nerves.

The action of the levators ani is to retract the anus and the rectum after it has been protruded in defæcation by the combined action of the abdominal muscles and the diaphragm.

Coccygeus. — This muscle is placed behind the levator ani, and should be regarded as a continuation of that muscle. It is triangular in shape, and *arises* by its apex from the spine of the ischium and the lesser sacro-sciatic ligament, gradually spreads out, and is *inserted* into the side of the lower part of the sacrum and the coccyx. Its posterior fibres are in relation with the pyriformis, its anterior fibres are continuous with the levator ani. This muscle is supplied by the two lower sacral and the coccygeal nerves.

Dissection. — At this stage of the dissection, the bladder should be drawn downwards, and the branches of the internal iliac artery and the sacral plexus clearly displayed on the right side, by carefully clearing away the prolongations of the pelvic fascia which surround them.

Internal Iliac Artery and Branches. — From the division of the common iliac artery, the *internal iliac* descends into the pelvis, and after a course of about an inch and a half (*3.8 cm.*) divides, opposite the great sacro-sciatic notch, into two large branches, an anterior and posterior (Fig. 191). The artery lies upon the lumbo-sacral cord, the pyriformis muscle, the external and internal iliac veins ; the ureter, enclosed in the posterior false ligament of the bladder, passing in front : the psoas lies to its outer side at the commencement of its course.

The *posterior* division gives off the ilio-lumbar, lateral sacral, and gluteal arteries ; the *anterior* gives off the superior vesical, obturator, inferior vesical, middle hæmorrhoidal, sciatic, and pudic ; also the uterine and vaginal in the female. Such is

their usual order; but these branches, though constant as to their general distribution, vary as to their origin.

The branches of the posterior division are —

a. The *ilio-lumbar* is analogous to the lumbar branches of the aorta. It ascends beneath the psoas and the external iliac vessels to get to the superficial surface of the iliacus. Here it divides into an iliac and a lumbar branch; the *iliac branch* supplies branches to the iliacus, a branch to the diploë of the ilium, and a large branch along the iliac crest, which finally inosculates with the deep circumflexa ilii, the epigastric, the gluteal, and the external circumflex arteries; the *lumbar branch* supplies the psoas and the quadratus lumborum, and anastomoses with the last lumbar artery; it distributes a small branch to the cauda equina, through the foramen, between the last lumbar and first sacral vertebræ.

b. The *lateral sacral*, usually two in number, an upper and a lower, descend in front of the sacral foramina, and inosculate on the coccyx with the middle sacral artery; the upper enters one of the upper sacral foramina, and, after supplying the structures in the sacral canal, emerges on the back through one of the

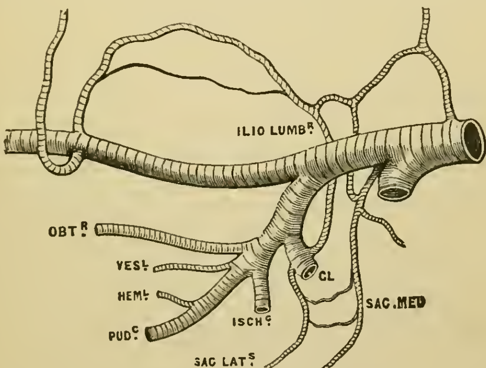


FIG. 191.—PLAN OF THE BRANCHES OF THE INTERNAL ILIAC ARTERY

posterior foramina and supplies the muscles in the neighborhood, anastomosing with the gluteal artery; the lower descends in front of the pyriformis, supplying branches to this muscle, the bladder, and rectum, and others which enter the anterior sacral foramina for the supply of the cauda equina, and finally emerge through the posterior sacral foramina to end in the muscles and skin of the back: this branch inosculates with the middle and lateral sacral arteries and the gluteal.

c. The *gluteal* is the largest branch. It passes immediately out of the pelvis through the great sciatic notch, above the pyriformis muscle, and then divides into a superficial and deep branch; the former passes beneath the gluteus maximus; the latter passes between the gluteus medius and minimus, and then divides into two branches, one running along the upper attached border of the gluteus minimus, the other passing obliquely across the same muscle as far as the great trochanter, to anastomose with the external circumflex artery. These will be dissected with the gluteal region.

The anterior division gives off —

a. The *superior vesical artery*, which comes off from the unobliterated portion of the hypogastric, and supplies the upper part of the bladder. It gives off the *middle vesical artery*, which supplies the base of the bladder and the vesicula

seminalis; a small branch, the *deferential*, which accompanies the vas deferens to the testis and inosculates with the spermatic artery; and smaller branches to the ureter.

b. The *inferior vesical artery*, which ramifies on the under surface of the bladder, the vesiculæ seminales, and the prostate, anastomosing with branches of the corresponding artery of the other side.

c. The *middle hæmorrhoidal artery*, which usually arises in conjunction with the preceding, and supplies the rectum, inosculating with the other hæmorrhoidal arteries.

d. The *obturator artery*, which runs along the side of the pelvis, below the corresponding nerve, to the upper part of the obturator foramen, through which it passes to be distributed to the muscles of the thigh. *In the pelvis* it lies between the peritoneum and the pelvic fascia, and gives off a small branch to the iliacus, which anastomoses with the ilio-lumbar; a *vesical branch*, which passes backwards to supply the bladder; and another, the *pubic branch*, which ramifies on the back of the os pubis, and inosculates with the corresponding branch of the deep epigastric artery and with its fellow of the opposite side. *External to the pelvis* it divides into an external and internal branch, which respectively skirt the outer and inner margins of the obturator foramen.

The obturator artery does not, in all subjects, take the course above stated,

FIG. 192.—VIEW OF THE DIFFERENT DIRECTIONS WHICH AN ABNORMAL OBTURATOR ARTERY MAY TAKE. (SEEN FROM ABOVE.)

A. 1. Gimbernat's Ligament. 2. Femoral ring. 3. Abnormal obturator artery. 4. External iliac vein. 5. External iliac artery. 6. Diminutive obturator artery arising from its normal source. B. 1. Gimbernat's ligament. 2. Abnormal obturator artery. 3. Femoral ring. 4. External iliac vein. 5. External iliac artery. 6. Diminutive obturator artery.

since, in one case in three and a half, it arises from the deep epigastric, and in one out of seventy-two cases it has its origin by a branch from the obturator joining a branch from the epigastric. It may arise from the external iliac near the crural arch, or by a short trunk in common with the epigastric.* Under these circumstances, in order to reach the obturator foramen, it generally descends on the *outer* side of the femoral ring. Instances, however, occasionally occur, where it makes a sweep round the *inner* side of the ring; so that three-fourths of the ring, or, what comes to the same thing, of the neck of a femoral hernia, would in such a case be surrounded by a large artery.

* In most subjects a small branch of the obturator ascends behind the ramus of the os pubis to inosculate with the epigastric. The variety in which the obturator arises in common with the epigastric is but an unusual development of this branch. The branch derives additional interest from the fact, that after ligature of the external iliac it becomes greatly enlarged, and carries blood directly into the epigastric. See a case in *Med. Chir. Trans.*, vol. xx., 1836.

e. The *sciatic* or *ischiatic artery* is the larger of the two branches into which the anterior trunk divides. It proceeds over the pyriformis and the sacral plexus, to the lower border of the great sciatic notch, through which it passes out of the pelvis between the pyriformis and coccygeus to the buttock, where it runs with the great sciatic nerve between the great trochanter and the ischial tuberosity. It gives off small *muscular branches* in the pelvis to the pyriformis, coccygeus, and levator ani; *vesical branches* to the bladder, prostate, and vesiculæ seminales; and *hæmorrhoidal branches* to the rectum.

f. The *internal pudic artery* supplies the perineum, scrotum, and penis. In the pelvis it usually lies above the sciatic, and rests upon the pyriformis and sacral plexus, having the rectum to its inner side. It passes out of the pelvis through the great sciatic foramen, below the pyriformis and above the coccygeus, crosses over the spine of the ischium, and re-enters the pelvis through the lesser foramen. It then ascends on the inner side of the obturator internus towards the pubic arch, where it gives branches to the several parts of the penis. In its passage on the inner side of the obturator muscle it is enclosed in a strong tube of fascia (*Canal of Alcock*), formed by the obturator fascia, and is situated about one inch and a quarter (*3.1 cm.*) above the tuberosity of the ischium. It now ascends under cover of the ascending ramus of the ischium, where it pierces that part of the pelvic fascia which forms the posterior layer of the triangular ligament, and continues its course close to the ramus of the os pubis, between the two layers of the ligament, the anterior layer of which it pierces, and then divides into the artery of the corpus cavernosum and the dorsal artery of the penis. Throughout its course it is accompanied by the pudic nerve and veins. The branches of the pudic artery were described in the dissection of the perineum (p. 506).

The pudic artery, however, sometimes takes a very different course. Instead of passing out of the pelvis, it may run by the side of the prostate gland to its destination; or, one of the large branches of the pudic may take this unusual course, while the pudic itself is regular, but proportionably small. Anatomists are familiar with these varieties, and a winter session rarely passes without meeting with several examples of them. It need hardly be said that lithotomy, under such conditions, might be followed by a large hæmorrhage.

The *middle sacral artery* is a small branch of the abdominal aorta at its point of bifurcation. It descends in front of the body of the fifth lumbar vertebra, the sacrum, and the coccyx. In its course it gives off small branches to the rectum, to the anterior sacral foramina, and it finally inosculates on the sacrum and the coccyx with the lateral sacral arteries. It gradually becomes smaller as it passes down and terminates near the tip of the coccyx in a small body about the size of a pea, called the *coccygeal* or *Luschka's gland*, which has been previously described (p. 479).

Respecting the *veins* in the pelvis, they correspond with the arteries, and empty themselves into the internal iliac vein. The remarkable plexus of veins about the prostate, neck of the bladder, and rectum, has been described (p. 516).

Nerves of the Pelvis. — Those which proceed from the spinal cord should be examined first, afterwards those derived from the sympathetic system.

Sacral Nerves. — Five sacral nerves proceed from the spinal cord through the anterior sacral foramina. The upper four, from their large size, at once attract observation; but the fifth is small: it perforates the coccygeus muscle, supplying it and the skin over the coccyx.

Sacral Plexus. — The anterior divisions of three upper sacral nerves, and part of the fourth, with the lumbo-sacral cord, form

the sacral plexus. The great nerves of this plexus lie on the anterior surface of the pyriformis, covered by the pelvic fascia, which separates it from the branches of the internal iliac vessels and the pelvic viscera. The large cords, diminishing in size from above downwards, converge from the sacral foramina to the great sacro-sciatic foramen, where they coalesce to form a broad flat cord, which passes out of the pelvis beneath the pyriformis muscle, for the supply of the flexor muscles of the inferior extremity.

Before describing the branches of the sacral plexus, it will be best to trace those sacral and coccygeal nerves which do not enter into the formation of the sacral plexus.

The lower part of the *fourth sacral nerve* lies on the coccygeus muscle, and divides into muscular and visceral branches, sending a filament downwards to join the fifth sacral nerve. It distributes branches to the pelvic viscera, and muscular twigs to the levator ani, the coccygeus, and sphincter, the latter of which also furnishes a small cutaneous filament to the skin between the bone and the anus.

The *fifth sacral nerve* emerges between the sacrum and the coccyx, pierces the coccygeus, and lies on its anterior surface. It is joined by a twig from the fourth sacral, and, after running a short distance, pierces the coccygeus again, and is distributed to the skin over the back of the coccyx. It communicates with the coccygeal nerve, and supplies the coccygeus muscle.

The *coccygeal nerve*, not easily found, emerges through the end of the sacral canal, and comes forwards through the coccygeus, between the first and second pieces of the coccyx. It pierces the great sacro-sciatic ligament, and, after receiving the communicating twig from the fifth sacral nerve, it passes backwards to supply the integument over the back and side of the coccyx. The communications between these three last nerves are sometimes described as the *coccygeal plexus*.

The *muscular branches* of the sacral plexus are as follows :—

a. Muscular branches, distributed to the pyriformis, the gemelli, the quadratus femoris, and the obturator internus. The *nerve to the obturator internus* is given off from the anterior aspect of the plexus (sometimes from the pudic), leaves the pelvis through the great sciatic foramen with the pudic artery, winds with it round the ischial spine, and re-enters the pelvis with the artery to reach the inner aspect of the obturator internus ; it distributes a small twig to the gemellus superior. The branch to the quadratus femoris is derived from the plexus near the preceding nerve ; it passes down, beneath the gemelli and obturator internus, to enter the anterior or deep aspect of the quadratus femoris, lying between this muscle and the cap-

sule of the hip-joint: it sends off a small twig to the inferior gemellus, and another to the hip-joint.

b. The *superior gluteal nerve* proceeds from the lumbo-sacral cord and the first sacral nerve, leaves the pelvis through the great sacro-sciatic foramen with the gluteal artery, above the pyriformis, and there divides into two branches; the *upper* passes along the iliac attachment of the gluteus minimus, supplying it and the gluteus medius; the *lower* accompanies the lower branch of the gluteal artery, and supplies the glutei medius and minimus and the tensor fasciæ femoris.

c. The *pudic nerve from the second, third, and fourth sacral nerves*, runs with the pudic artery, and is contained in the same sheath of the obturator fascia; it divides into two branches — the perineal nerve, and the dorsal nerve of the penis; the *former* accompanies the superficial perineal artery, and supplies cutaneous branches and muscular branches to the external sphincter, the accelerator urinæ, the transversus perinei, the erector penis, and the compressor urethræ; the *dorsal nerve* accompanies the last part of the pudic artery, and, after piercing the anterior layer of the triangular ligament and the suspensory ligament, runs along the dorsum of the penis external to the dorsal artery, and is distributed to the glans and the prepuce.

d. The *small sciatic nerve from the second and third sacral nerves* passes through the great sacro-sciatic foramen below the pyriformis, and then divides into two branches: one, a motor — the *inferior gluteal* — supplies the gluteus maximus; the other, *long pudendal nerve, or nerve of Soemmerring*, a sensory, supplies cutaneous branches to the back of the thigh and leg, to the skin over the gluteus maximus, and to the perineum and scrotum. These will be dissected later on with the lower extremity.

e. The *great sciatic nerve from a part of the fourth lumbar nerve*, "NERVE FURCALIS," *joining the fifth lumbar-nerve to form the lumbo-sacral cord. This cord is joined by the first, second, and third sacral nerves* making a large nerve-cord which passes along the back of the thigh anterior to the gluteus maximus and the hamstring muscles, and will be dissected at a later stage.

Pelvic Sympathetic Plexus. — From the lumbar region the sympathetic nerve descends into the pelvis along the inner side of the anterior sacral foramina. In this part of its course its ganglia vary in number from four to five. The nerves of opposite sides unite in front of the coccyx, where they form the *ganglion impar*.

FIG. 193.—SACRAL PLEXUS AND LUMBAR PLEXUS. (From "POTTER.")

The arrangement of the sympathetic nerves in the pelvis is similar to that in the abdomen, each ganglion receiving a branch from the ganglion above and another from the ganglion below. The external branches communicate with the sacral nerves, one probably going to, and the other coming from, the spinal nerves; the internal branches pass partly to join the pelvic plexus, and partly to the plexus around the arteria sacra media.

The *pelvic plexuses* are two in number, and are situated one on each side of the rectum, being derived from the hypogastric plexus, which passes downwards between the common iliac arteries into the pelvis, reinforced by filaments from the second, third, and fourth sacral nerves and ganglia. The visceral branches are exceedingly delicate, and cannot be traced unless the parts have been previously hardened in spirit. They accompany the arteries supplying the respective organs, and are the *inferior hæmorrhoidal plexus* to the rectum; the *vesical plexus* to the sides and base of the bladder, and secondary plexuses to the vas deferens and vesicula seminalis; the *prostatic plexus* to the prostate, the vesicula seminalis, and the cavernous structure of the penis; and, in the female, the *vaginal plexus* to the vagina and its erectile tissue, and the *uterine plexus* to the neck and lower part of the body of the uterus, running between the layers of the broad ligament. It also distributes numerous filaments to the fundus of the uterus and the Fallopian tubes.

STRUCTURE OF THE BLADDER, PROSTATE, URETHRA, AND PENIS.

It is assumed that the parts have been collectively taken out of the pelvis, and that the partial peritoneal covering of the bladder has been removed.

Structure of the Bladder. — The bladder, in a fairly dilated condition, measures about five inches (*12.5 cm.*) in length and three (*7.5 cm.*) in breadth, and when moderately full will contain about a pint (*472 c.c.*) of urine. The bladder is composed of a partial peritoneal coat, a muscular and a mucous; between the last two there is a layer of connective tissue, which is called the cellular coat.

The *serous* or *peritoneal coat* invests the posterior, lateral, and superior surfaces of the bladder: it is absent on the anterior and inferior aspect.

The *muscular coat* is situated beneath the serous, and consists of unstriped muscular fibres, which interlace with each other in all directions. Their general arrangement is as follows: An *outer*, or *longitudinal*, layer arises from the pubo-prostatic ligaments, the upper half of the circumference of the prostate and the neck of the bladder, and thence its fibres spread out longitudinally over the summit of the bladder, pass round its posterior aspect and base, to be inserted into the prostate in the male, and the vagina in the female. This layer is especially marked on the anterior and posterior surfaces of the bladder. There are also some lateral longitudinal fibres which pass back-

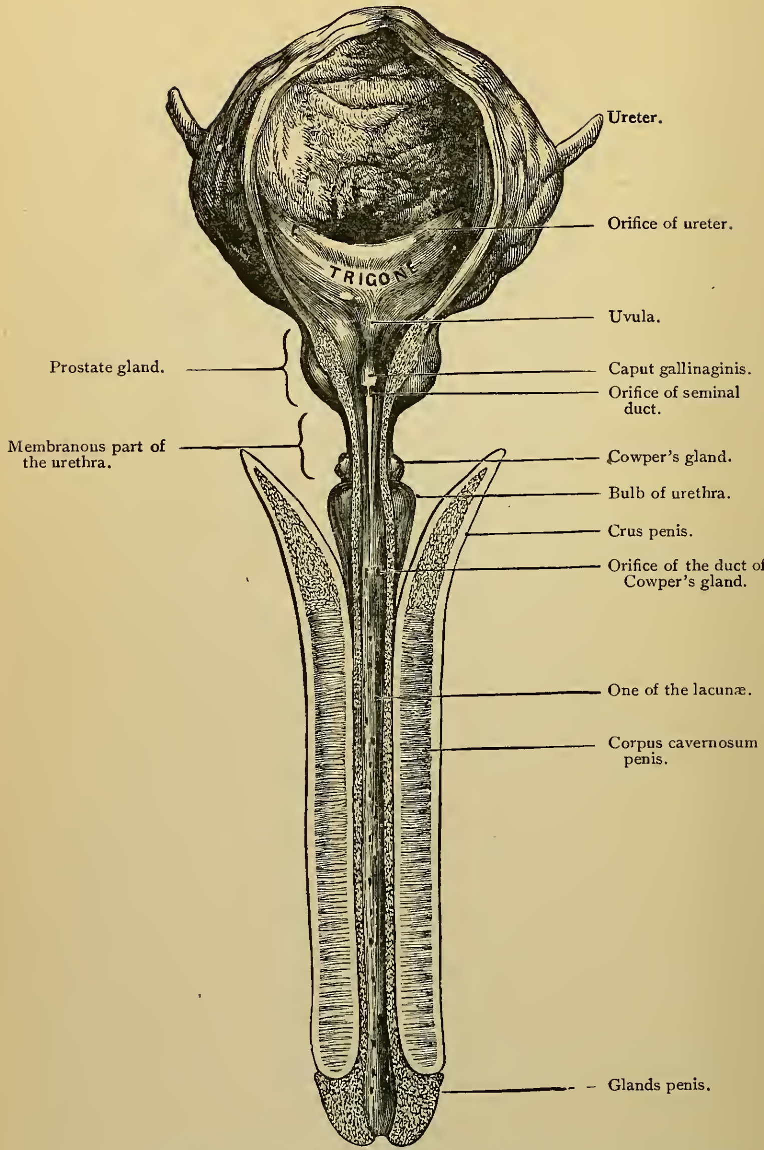


Fig. 194.—Bladder and Urethra, Laid Open by an Incision along the Upper Surface.

wards from the sides of the prostate and interlace in all directions. Between these is a thin layer of *circular fibres*, especially developed near the neck and the commencement of the urethra, where they form a sphincter — *sphincter vesicæ*. Towards the sides of the bladder the two sets of fibres have a less definite arrangement and form a kind of network; these, therefore, are the weakest parts of the bladder, and more liable to the formation of pouches.* The development and color of the muscular fibres depend upon how far the subject has suffered from irritation of the bladder, or any obstruction to the expulsion of the urine.

The *cellular coat* loosely connects the muscular with the mucous coat, and is firmly adherent to the latter.

The bladder must be laid open by an incision along its front, to examine its interior. In a recently contracted bladder, the mucous membrane is disposed in irregular folds, which disappear when the bladder is distended. In a healthy state it is smooth, soft, and pale pink color; when inflamed, it becomes of a bright red. Under the microscope its surface is seen to be studded with mucous follicles. These follicles secrete the thick ropy mucus in inflammation of the bladder.

The *mucous coat* is loosely connected with the subjacent muscular layer, except at the *trigone* (*of Lieutaud*) of the bladder, where it is firmly adherent. The epithelium is composed of flattened polyhedral cells of the transitional variety, and beneath these there have been described by Klein a layer of large club-shaped cells arranged at right angles to the surface.

When the interior of the bladder is examined, there is seen immediately behind the urethra a triangular smooth surface, measuring three-quarters of an inch to an inch (*18* to *25 mm.*), the apex being at the urethra. This surface is called the *trigonum vesicæ*, and is paler and smoother than the vesical mucous membrane elsewhere; laterally it is bounded by ridges extending from the urethra to the orifices of the ureters, the base being between the two ureters. This space corresponds with

* These pouches arise in the following manner: A portion of mucous membrane is protruded through one of the muscular interstices, so as to form a little sac. This is small at first, but gradually increases in size, because, having no muscular coat, it has no power of emptying itself; generally speaking, several such sacs are met with in the same bladder, and they sometimes contain calculi. If a calculus, originally loose in the bladder, happen to become lodged in a pouch by the side of it, a sudden remission of the symptoms may ensue. This explains our occasional inability to detect its presence at each examination with the sound.

another one already described external to the bladder, and which is bounded laterally by the vesiculæ seminales, and behind by the reflection of the peritoneum. It is more richly provided with blood-vessels and nerves than the rest of the bladder, and is endowed with more acute sensibility. This is why a stone is more painful when the bladder is empty, and in the erect than in the recumbent position.

The *vesical orifice of the urethra* is situated at the lower and anterior part of the bladder, not at the most dependent part, which forms the pouch behind the orifice, in which urine is apt to accumulate in old persons. It appears small and contracted in the fresh bladder, but, if the little finger be introduced into it, it will dilate considerably. Immediately behind the orifice there is, in some bladders, a slight elevation called the *uvula of Lieutaud*. It is composed of a portion of the mucous membrane raised up by an accumulation of the prostatic and submucous tissue, but is rarely of sufficient size to interfere with the passage of the urine. This elevation must be distinguished from enlargement of the third or middle lobe of the prostate.

The *orifices of the ureters* are situated about an inch and a half (*3.8 cm.*) behind the urethra, and about three-quarters of an inch to an inch (*18* to *25 mm.*) apart. These tubes perforate the coats of the bladder obliquely, and slant towards each other, standing out in relief under the mucous membrane.* A slight ridge proceeds from the orifice of each ureter to the neck of the bladder, looking like a continuation of the ureter itself. If the mucous membrane be removed from these ridges, we find that they are produced by muscular fibres. Sir Charles Bell,† who first drew attention to them, believed them to be of use in regulating the orifices of the ureters, and named them *the muscles of the ureters*.

The bladder is supplied with blood by the *superior*, *middle*, and *inferior vesical* arteries. The superior comes from the unobliterated portion of the hypogastric; the middle, from the superior vesical or the internal iliac; the inferior, from the

* This slanting of the ureters serves all the uses of a valve. The urine enters the bladder, drop by drop, but cannot return, because the internal coat is pressed against the other side of the orifice, so as to stop it. When the bladder becomes thickened, in consequence of difficulty in passing urine, it sometimes happens that the ureters lose their valvular direction, so that the urine, when the bladder contracts, is partly forced back up the ureters: the result is, that they become dilated, and the pelvis of the kidney also.

† *Med. Chir. Trans.*, vol. iii. He says: "These muscles guard the orifices of the ureters by preserving the obliquity of the passage, and pulling down the extremities of the ureters according to the degree of the contraction of the bladder generally."

anterior division of the internal iliac or the pudic. Small branches are also distributed to the bladder by the obturator and sciatic arteries.

The *veins* of the bladder form large plexuses around its neck, sides, and base, and empty themselves into the internal iliac veins. The *lymphatics* follow the course of the veins.

Its *nerves* are derived from the hypogastric and sacral plexuses; the former is chiefly distributed to the top, the latter to the neck and the bottom of the bladder.

Prostate. — Having already examined the form, size, and relations of the prostate (p. 522), we have now to make out its lobes. There are *two lateral lobes* presenting on their upper and lower surfaces a median longitudinal furrow, the lower groove terminating behind in a deep cleft; and a third or *middle lobe.* The middle one is pyriform in shape, unites the lateral lobes, and is situated between them and the urethra. In health it does not appear like a separate lobe; but when abnormally enlarged, it projects toward the cavity of the bladder, and acts like a bar at the mouth of the urethra.

Make a longitudinal incision through the upper surface of the prostate to expose the urethra.

Prostatic Urethra. — This canal runs rather nearer to its upper than its lower surface, and is not of the same calibre throughout. This part of the urethra is about an inch and a quarter (*3.1 cm.*) long, and about $\frac{1}{3}$ of an inch (*8.3 mm.*) in diameter. It is U-shaped, the concavity being ventral. It forms a sinus in the interior of the prostate, described by anatomists as the *sinus of the prostate,* into which the ducts of the prostate open. Along the floor of the sinus is a longitudinal ridge, about three-quarters of an inch (*18 mm.*) in length, broad and elevated behind, but gradually fading in front. This is called the crest of the urethra, and the most prominent part of it is named the *veru montanum,* or *caput gallinaginis,* from its supposed resemblance to the head of a woodcock. On each side of this prominence the common ejaculatory ducts open (Fig. 194, p. 532).

Immediately in front of the caput gallinaginis, in the middle line, is a small opening which will admit a probe. It leads backwards into a little cul-de-sac or pouch in the substance of the prostate. This pouch is described as the analogue of the uterus, and called the *utriculus* or *sinus pocularis.* It is also called the *uterus masculinus.* It is of a pyriform shape, running backwards and upwards with the narrowest part of the orifice, and its length is about $\frac{1}{4}$ of an inch (*6 mm.*). It ascends between the lateral lobes of the prostate, and beneath the

middle; its coats are comparatively thick with some muscular tissue enclosed in them, and it is lined with squamous epithelium. The minute orifices of the ducts are seen opening into the floor of the prostatic sinus. The substance of the gland is permeated by the divisions and subdivisions of the ducts. They are not visible to the naked eye, but if traced out with the microscope they are seen to terminate in blind sacculated extremities, upon which the capillaries ramify in rich profusion.*

Structure of the Prostate. — The prostate is surrounded by a firm capsule of fibrous tissue, and is composed of muscular as well as glandular tissue. Nearly two-thirds of it is made up of unstriped *muscular fibres*, which constitute the stroma of the gland, and have the following arrangement: externally, beneath the capsule, they form a thick layer, continuous behind with the external muscular layer of the bladder; and in front they are arranged in a circular manner round

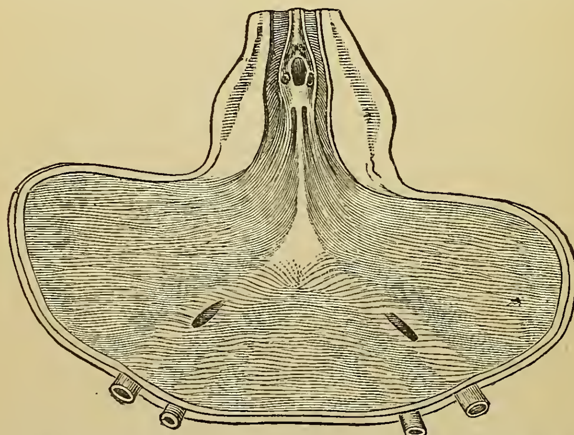


Fig. 195. — Lower Part of the Human Bladder Laid Open: showing clear part or trigone, one, the slit-like openings of the ureters, the divided ureters and vesiculæ seminales: the sinus prostaticus, and on each side of it the openings of the ejaculatory ducts and below both numerous small apertures of the prostatic ducts.

the urethra at its vesical orifice, so as to form in conjunction with the vesical muscular tissue, a sphincter; the next layer forms a dense interlacing stratum, in the meshes of which is found the glandular tissue; the deepest layer consists of a thick layer of circular fibres, blending posteriorly with the internal vesical muscular layer, and continuous in front with those of the membranous part of the urethra. The anterior part of the prostate is chiefly muscular; posteriorly, the glandular elements predominate.

The *glandular tissue* consists of numerous tubular alveoli, which open into

* This was first demonstrated by the late Mr. Quekett. The same anatomist has also discovered that the secreting cells of the gland contain calculi of microscopic minuteness. He finds them, almost without exception, in the prostate at every period of life. For further detail concerning them, consult the article 'Prostate' in Todd's *Cyclopædia*.

elongated excretory ducts lined with columnar epithelium. The alveoli are connected together by connective tissue, associated with fibrous prolongations from the capsule of the gland, and with the muscular tissue. The excretory ducts are from twelve to twenty in number, and open into the prostatic sinus in the floor of the urethra.* The prostate is remarkable for its dilatability. If a small incision be made through the anterior part of the gland, the *base being left entire*, the gland may be dilated by the finger sufficiently to allow the extraction of even large calculi.

Any change in the dimensions of the prostate affects the canal which runs through it, and more or less obstructs the flow of urine. If the entire gland be uniformly enlarged, the length of the prostatic urethra is increased; if the enlargement preponderate at one part more than another, then the canal will deviate more or less from its natural track, and assume a more angular or a lateral curve according to the part enlarged. When the middle lobe becomes enlarged, there arises, at the neck of the bladder, a growth which will, in proportion to its size, more or less obstruct the passage of the urine. In the efforts made to introduce a catheter into the bladder, it sometimes happens that the end of the instrument is pushed through this hypertrophied lobe.

The prostate is supplied with *arteries* from the internal pudic, the inferior vesical, and the hæmorrhoidal; its *veins* form a plexus, the prostatic, around the gland, receiving in front the dorsal vein of the penis, and ending behind in the internal iliac vein; its *nerves* are derived from the hypogastric plexus, and are interspersed with ganglion cells; the *lymphatics* pass to the internal iliac glands.

Vesiculæ Seminales. — The external appearance of these bodies, each of which consists of a tube coiled upon itself, has been already described (p. 522). Respecting their structure, we find that they have an *external* or *connective-tissue coat* derived from the recto-vesical fascia; a *middle* or *muscular*, consisting of superficial fibres arranged transversely, and of deep fibres arranged longitudinally, and continuous with those of the urethra; and an *internal* or *mucous*, which is lined by a scaly epithelium, and presents a honeycombed structure, not unlike that of the gall-bladder. The duct emerges from the anterior part of the vesicula, and joins at an acute angle the vas deferens behind the prostate, to form the common ejaculatory duct (p. 519). Its *arteries* come from the inferior vesical and middle hæmorrhoidal; its *veins* pass to the internal iliac vein, and its *nerves* are derived from the hypogastric plexus. The function of these bodies is twofold — they act as reservoirs for the semen, and secrete a fluid accessory to generation.

Cowper's Glands. — The glands of Cowper have been examined *in situ* in the dissection of the perineum (p. 506). They are placed close to the urethra, one on either side, immediately behind the bulb and between the two layers of the triangular ligament. They are pea-like bodies consisting of a number of lobules united by firm connective tissue. Each pours its secretion by a minute duct, about an inch (*2.5 cm.*) long, into the bulbous part of the urethra. The use of these glands is analogous to that of the vesiculæ seminales and the prostate — namely, to pour into the urethra a fluid accessory in some way to generation. They are found in all mammalia, and in some, *e.g.*, the mole, they increase in size periodically with the testicle.

Urethra. — The urethra is the canal which extends from the bladder to the end of the penis, and serves not only as the outlet for the urine, but to transmit the secretion of the testicles and the several glands accessory to generation. It varies in

* In the ducts of the prostate we often find small calculi, of a brown color, consisting of phosphate of lime. Cases are sometimes met with in which these calculi by degrees attain a considerable size, and distend the prostate into a sac, which, when examined by the rectum, feels not unlike a bag of marbles.

length from eight to nine inches (*20–22.5 cm.*), and is divided into three portions, according to the different structures by which it is surrounded in different parts of its course. The first inch and a quarter (*3.1 cm.*) is surrounded by the prostate gland, and is called the *prostatic portion;* the next three-quarters of an inch (*18 mm.*) which passes under the pubic arch, is surrounded by the compressor urethræ, and is termed the *membranous portion;* the remainder of its course, about six inches (*14 cm.*) in length, is contained in the corpus spongi-

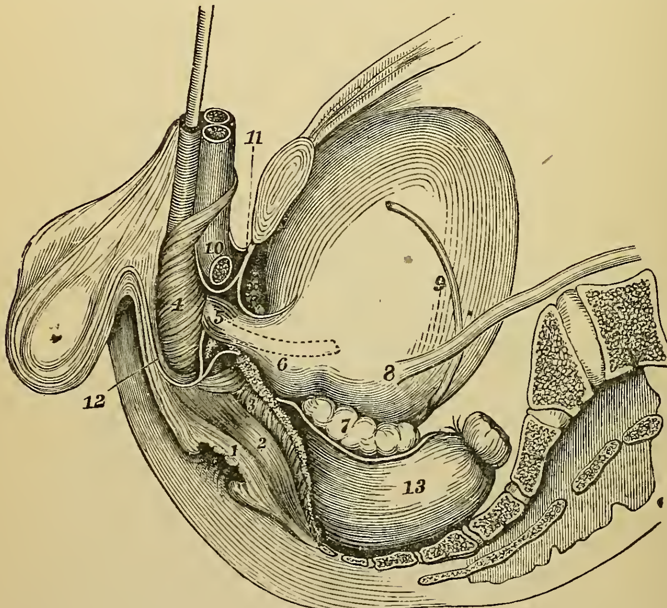


FIG. 196.—SIDE VIEW OF THE PELVIC VISCERA.
(Taken from a Photograph.)

1. External sphincter. 2. Internal sphincter. 3. Levator ani cut through. 4. Accelerator urinæ. 5. Membranous part of the urethra, surrounded by compressor muscle. 6. Prostate gland. 7. Vesicula seminalis. 8. Ureter. 9. Vas deferens. 10. Crus penis divided. 11. Triangular ligament. 12. Superficial perineal fascia. 13. Rectum.

osum, and is called the *spongy portion.* The length of the urethra will vary much in different subjects, and according to the condition of the penis.

The direction of the urethra, when the penis hangs flaccid, is like the letter S reversed; but if the penis be held straight, the canal forms only one curve through the pubic arch, with the concavity upwards. The degree of this curvature varies at

different periods of life. In the child, the bladder being more an abdominal than a pelvic viscus, the curve forms part of a much smaller circle than in the adult; but it gradually widens as age increases, and catheters are shaped accordingly. However, the parts, when in a sound state, will yield sufficiently to admit the introduction of a straight instrument into the bladder. A straight staff is sometimes used in lithotomy.

In its contracted state, the sides of the urethra are in close apposition; the appearance it presents on a transverse section differs in the different parts of its course. Through the glans it is flattened vertically; through the prostate it is crescentic, with its convexity upwards, owing to the veru montanum. But throughout the rest of its course the canal exhibits on section the appearance of a transverse slit (Fig. 197).

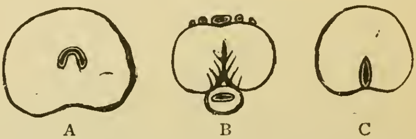


FIG. 197.—TRANSVERSE SECTIONS OF THE URETHRA.

A. Through the prostate. B. Through the corpus spongiosum. C. Through the glans penis.

The urethra must be laid open from end to end along its roof, to see that the canal is not of uniform calibre throughout. The external orifice is the narrowest and the least dilatable part; so that the urine may be expelled in a jet.* Therefore, any instrument which will enter the meatus ought to pass into the bladder, if there be no stricture. The junction of the membranous with the bulbous part is almost as narrow.

The *prostatic portion* of the urethra has been described with the prostate (p. 535); the *membranous portion* with the anatomy of the side view of the pelvic viscera (p. 523).

The *spongy portion*, so termed because it is surrounded by the erectile tissue of the corpus spongiosum, is about six inches (*14 cm.*) long. That part of it running through the bulb is called the *bulbous portion*, and is the most dilatable part of the urethra except the prostatic. In the centre of the glans penis the canal widens into a sinus termed *fossa navicularis;* its termination, at the *meatus urinarius*, is the most contracted part of the urethra.

The most *dilatable* part of the urethra is the prostatic. Even

* Otis's investigations show that a penis of *36 mm.* in circumference will admit a bougie of *16 mm.*; *i.e.*, there is a relative proportion of the size of the organ to that of the urethra of four to nine. This rule is not absolute, but is a good guide in selecting the bougie or catheter to be used for the first time. — A. H.

the narrowest parts of the canal must admit of considerable dilatation, since calculi of from $\frac{1}{4}$ to $\frac{1}{3}$ of an inch (*6 to 8 mm.*) in diameter can pass through it.

The common ejaculatory ducts (Fig. 194, p. 532) open into the prostatic part of the urethra, by the side of the veru montanum. The ducts of Cowper's glands open into the bulbous part. Besides these glands, a number of ducts open into the urethra, proceeding from small glands situated in the submucous tissue. These ducts, called the *glands of Littré*, or *lacunæ*, are large enough to admit a bristle, and run in the same direction as the stream of the urine. Most of them are on the lower surface of the urethra; but one, called *lacuna magna*, is on the upper surface, about one inch and a half (*3.8 cm.*) down the canal.

The urethra is composed of three coats — a mucous, muscular, and erectile.

The *mucous coat* is continuous posteriorly with that of the bladder, and it sends down prolongations into the various ducts which open into it. It is arranged in longitudinal folds in the membranous and spongy portions, and is lined by columnar epithelium except near the glans, where there are papillæ, covered with squamous epithelium; this, therefore, is the most sensitive part.

Beneath the mucous membrane is a double layer of *unstriped muscular tissue*,* the superficial fibres being arranged longitudinally, the internal fibres circularly. The superficial fibres are continuous with those of the bladder, the external fibres of which surround the spongy portion of the urethra, being placed between it and its fibrous capsule; the deeper fibres of the bladder pass forwards, surrounding the prostatic urethra, and subsequently the spongy urethra, immediately beneath the mucous membrane. Between the mucous and muscular coats is a layer of areolar tissue, the *submucous tissue*.

The *erectile coat*, a thin stratum of erectile tissue derived from the corpus spongiosum, extends from this body round the membranous and the prostatic portions of the canal.

Lastly, the urethra is provided with a closely set network of *lymphatic vessels*, which has been demonstrated by quicksilver injections. They run from behind, forwards, and join the lymphatics of the glans penis. Eventually, their contents are transmitted down the great trunks on the dorsum penis to the inguinal glands. This explains the pathology of a bubo.

The Penis. — The *penis* is a pendulous organ through which runs the urethra for three-fourths of its course; it consists of a root, a body, and the glans penis. The *root* is the broadest part, and is connected by two crura to the rami of the pubic bones; its dorsum being supported by a strong elastic suspensory

* The vermicular action of the muscular coat of the urethra is in evidence from its action upon a catheter left in the canal and upon bodies introduced therein: the former being expelled, and the latter, when not as long as the urethra, being sucked into the bladder — there to become the nucleus of a stone. — A. H.

ligament, which is attached to the symphysis pubis. The *body* is cylindrical, consisting of the two corpora cavernosa and the corpus spongiosum. The *glans* is the expanded extremity which presents at its apex the orifice of the urethra, and at its base where it is attached to the body there is a deep circular groove, the *cervix*, the elevated margin in front being called the *corona glandis.* In these situations are a number of minute sebaceous glands, *glandulæ Tysonii odoriferæ*, which secrete a sebaceous substance, called smegma preputii. The surface of the glans has no sebaceous glands, but is covered with minute vascular papillæ, endowed with keen sensibility by the dorsal nerves of the penis. The skin of the penis is remarkably thin and extensible, and connected to the body of the organ by loose areolar tissue, destitute of fat. At the extremity the skin forms the prepuce, or foreskin, for the protection of the glans;* and the thin fold which passes from the under surface of the glans to the prepuce is called *frænum preputii.* The skin, altered in character, is reflected over the glans, to which it is intimately adherent, and at the orifice of the urethra is continuous with the mucous membrane.

The bulk of the penis consists of two parallel cylindrical bodies, of erectile structure, named from the appearance of their interior *corpora cavernosa.* In a groove along their under surface is lodged a third cylindrical body, the *corpus spongiosum*, composed of vascular spongy tissue, through which runs the urethra; an expansion of this at the end of the organ forms the *glans.* These structures, then — the corpora cavernosa and the corpus spongiosum — together form the penis; though the corpus spongiosum appears closely united to the corpora cavernosa, yet it is quite distinct from them, as shown in the transverse section (Fig. 198).

Corpora Cavernosa. — The *corpora cavernosa*, placed side by side, constitute more than two-thirds of the bulk of the penis. Each commences posteriorly by a gradually tapering portion, called the *crus penis*, which is attached along a groove in the

* When the foreskin is, from birth, so tight that the glans cannot be uncovered, such a state is called a congenital phymosis. This condition occasions no inconvenience in childhood, but is apt, after puberty, to become troublesome and painful, so that it may become necessary to slit up the prepuce and set the glans at liberty. In persons who have a tight foreskin, it sometimes happens that, when the glans has been uncovered, the prepuce cannot be again drawn over it: this is called a paraphymosis. The neck of the glans becomes tightly girt; great distension and inflammation are the consequences unless the foreskin be reduced.

rami of the ischium and os pubis, where it is embraced by the erector penis (p. 500). The two crura converge, come into apposition at the root of the penis, prior to which each presents an enlargement, less in man than in some animals, called the *bulb of the corpus cavernosum ;* they then run together, side by side, to form the body of the organ. Anteriorly, each terminates in a rounded extremity, received into a corresponding depression in the glans, to which it is connected by fibrous tissue.

A section through the corpus cavernosum shows that its interior is composed of a delicate reticular structure, surrounded by a white fibrous and elastic coat, from $\frac{1}{25}$ to $\frac{1}{12}$ of an inch (*1 to 2 mm.*) in thickness, and is separated from its fellow by a fibrous septum called the *septum pectiniforme.*

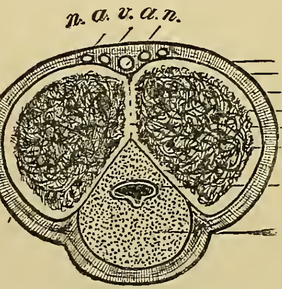


Fig. 198. — Transverse Section of the Middle Third of the Body of the Penis. *n.* Nerve. *a.* Artery. *v.* Vein.

The *septum pectiniforme* is a median vertical partition between the two corpora cavernosa; it is only complete near the root of the penis; along the rest of the organ there are vertical slits in it, giving it the appearance of a comb; hence its name. Through the intervals in this partition the blood-vessels of the two corpora cavernosa communicate freely with each other.

The *fibrous investment* is thick and strong, and consists of longitudinal bundles of white fibrous tissue, intermingled with yellow elastic fibres. From the interior of the fibrous coat numerous delicate septa, *trabeculæ*, pass into the interior of the corpus cavernosum, intersecting each other in all directions, dividing it up into a multitude of small spaces. This trabecular tissue consists of fibrous lamellæ, with elastic and some non-striated muscular tissue. The spaces, lined by a layer of flattened epithelium cells, similar to that of veins, communicate freely with each other, as may be readily ascertained by blowing air into the penis; they are smaller, and their component septa thicker at the circumference than in the centre of the corpora cavernosa, at the root than towards the glans. Each corpus cavernosum thus consists of innumerable spaces mainly occupied by dilated venous sinuses, from which the blood is conveyed by the dorsal vein, the prostatic plexus, and the pudendal veins. When the penis is flaccid, these spaces are empty; when it is erect, they are distended with blood.

The arteries of the corpora cavernosa come from the branches of the pudic (p. 506), which enter the inner side of each crus, at its bulbous enlargement, and proceed forwards near the septum, distributing numerous ramifications. These

are supported in the middle of the fibrous trabeculæ, and end, some in capillaries which convey their blood at once into the intertrabecular spaces; others in tendril-like prolongations with dilated extremities which project into the spaces, called *helicine arteries* by Müller, and which open directly into the cavities of the veins by funnel-shaped orifices. The helicine arteries are absent near the glans, and are best marked at the root of the penis. The peculiar appearance which they present when distended with injection is due to the fact that they are bound down to the trabecular tissue by fibrous bands.

The blood from the intertrabecular spaces of the penis returns, partly through veins which pass out on the upper surface of the penis into the dorsal vein (which joins the prostatic plexus), partly through the deep veins which leave the inner side of each crus and the bulb to join the internal iliac.

Corpus Spongiosum. — The *corpus spongiosum* is the erectile tissue which surrounds the urethra as it runs along the penis. It commences in the middle of the perineum, anterior to the triangular ligament, in a bulb-like form — *the bulb* — and at the end of the penis it expands to form the *glans penis*. It receives posteriorly an expansion from the triangular ligament, and presents a median groove, marking its development from two lateral halves. The urethra does not pass through the middle of the spongy body, but runs nearer to its upper surface. The bulb hangs more or less pendulous from the urethra, and is surrounded by the accelerator urinæ muscle (p. 500). In old persons it extends lower down than in children, and is, consequently, more exposed to injury in lithotomy.

The corpus spongiosum has a fibrous coat resembling very much the external fibrous investment of the corpus cavernosum, but it is thinner, whiter, and composed of more elastic tissue. The reticular structure is also finer, and the cavernous meshes smaller, and arranged in a longitudinal direction. Plain muscular fibres surround the urethra, and they are also found in considerable amount in the external fibrous coat.

Its interior consists of erectile tissue, composed of a plexus of minute tortuous veins, lined by a single layer of flattened endothelial cells, and which communicate very freely with each other. This is easily demonstrated by injecting the dorsal vein of the penis with wax. In this way, we not only fill the spongy body, but also the glans, and the large veins which form the plexus round the corona glandis.

The *veins* return the blood; some by small veins, which emerge from the glans and collect on the dorsal surface to form the dorsal vein; others pass into the dorsal vein, either through the corpora cavernosa, or by curving round the sides of the corpora cavernosa; but by far the larger number join the prostatic and the pudic veins, communicating also with the subcutaneous veins of the penis and the scrotum.

The *nerves* of the penis are the *pudic* and its *superficial perineal branch*. The largest branches run along the dorsum to the surface of the glans; a few only enter the erectile tissue of the organ. The pudic nerve and its branch supply the skin and the mucous membrane. Some of the filaments distributed to the glans have connected with them Pacinian bodies, and some end in simple and compound end-bulbs. The erectile tissue is supplied by numerous filaments proceeding from the *hypogastric plexus*.

The *lymphatics* consist of a superficial and a deep set; the *superficial*, proceeding from the glans and the integument of the penis, join the inguinal glands. The lymphatics of the glands communicate freely all round it: this explains why a venereal sore on one side sometimes affects the inguinal glands on the other. The *deep* lymphatics from the corpora cavernosa and the corpus spongiosum pass beneath the pubic arch and join the lymphatics of the pelvis.

DISSECTION OF THE FEMALE PELVIC VISCERA.

Side View of the Female Pelvic Organs. — After the removal of the left innominate bone, as described in the dissection for the side view of the male pelvic viscera, the vagina, rectum, and bladder should be moderately distended, the two former with tow, the latter with air. This done, the reflections of the peritoneum must be traced, the description of which will be found in the dissection of pelvic viscera from above (Fig. 179, p. 494). After this, clean off the peritoneum, and make out the pelvic fascia and its prolongations.

Pelvic Fascia. — To the description of the fascia already given in the dissection of the male pelvis (p. 513), nothing need be added, except that from the side of the pelvis it is reflected over the side of the vagina and the uterus, as well as the bladder.

It is this fascia which in great measure supports the uterus in its proper level in the pelvis. When, from any cause, the fascia becomes relaxed, there is a liability to prolapsus uteri.

Levator Ani. Bladder. — For the description of this muscle, see p. 523. The female bladder is broader transversely, and, upon the whole, more capacious * than the male. The vesical plexus of veins is not so large, and there are no vasa deferentia or prostate gland. The short urethra has a constrictor muscle, as in the male, and is supported in a similar manner by the pelvic fascia.

Venous Plexus about the Vagina. — Though the veins round the neck of the bladder are comparatively small in the female, attention should be directed to the plexus of large veins which surround the vagina. They communicate freely with the veins about the rectum, and empty themselves into the internal iliac. Their congestion in pregnancy sufficiently accounts for the dark color of the vagina and the external organs, and the frequent occurrence of hæmorrhoidal tumors.

* This is only so from force of habit, for the organ is really smaller than in the male. — A. H.

These veins must be removed, with the connective tissue in which they are embedded, before a clear view of the parts can be obtained.

Urethra. — The urethra has already been described (p. 510). But, in the side view of the parts, we have the opportunity of observing how closely the bladder and urethra are connected to the upper wall of the vagina; and we can understand how, in cases of protracted delivery, it sometimes happens that the contiguous coat of the bladder and the vagina give way, and that a fistulous communication remains between them, through which urine constantly dribbles.

Vagina. — It is necessary to slit open the whole of the vagina along the side to obtain a clear idea of the manner in which it embraces the lower end of the uterus, and of the extent to which the neck of the uterus projects into it (Fig. 179, p. 494).

The length of the vagina, in the unimpregnated adult, is about two and three-fourths inches (*6.8 cm.*) on its anterior wall, and three and three-fourths inches (*9.3 cm.*) along its posterior wall, owing to its curved direction.* It may be more or less, the difference in each case depending upon the depth of the pelvis, the stature, and age of the individual. The vagina, however, is never so long that we cannot, during life, feel the neck of the uterus projecting at the top of it, higher up, or lower down, according to circumstances. For instance, it is a little lower down in the erect than in the recumbent position; again, in the early months of utero-gestation the uterus descends a little into the vagina, so that this canal becomes shorter: the reverse holds good when the uterus begins to rise out of the pelvis.

The axis (*curve of Carus*) of the vagina is slightly curved with the concavity upwards; it corresponds with the axis of the outlet of the pelvis.

The width of the vagina is not uniform throughout. The narrowest part is at the orifice; it is also a little constricted round the neck of the uterus. The curve of the vaginal mucous membrane from its wall to the neck of the uterus is called the *fornix*. The widest part is about the middle; here a transverse section through it presents the appearance of a flattened H. If, therefore, you would insert the bivalve specu-

* This is subject to great variations, especially in the African, where it is longer and more capacious. — A. H.

lum with the least amount of pain, the blades of the speculum should be vertical when introduced into the orifice, and afterwards turned horizontally.

Relations. — The relations of the vagina to the bladder and urethra in front have been given. The ureters pierce the bladder wall in front of the vagina an inch and a quarter below the level of the os uteri, a point to be remembered in vaginal hysterotomy. *Behind* it is in contact with the *pouch of Douglas* for a short distance above, and separated from the rectum by this pouch and connective tissue. In the middle the rectum advances to the vagina, but in the lowest portion the perineal body separates them as the two canals diverge. *Laterally* the vaginal branches of the uterine arteries and veins are to be found in the subperitoneal tissue. In the upper third the ureters cross to the anterior surface, and in the lower thirds the mesial fibres of the levator ani muscle are to be found. In a digital examination of the vagina the pelvic wall can be distinguished, and any effusion between it and the vagina easily found. A fibrous cord may be felt on the sides in the upper half of the vagina ; it is the *duct of Gärtner*, the remains of the Wolffian duct. *Skene's tubes* are the ducts of *Gärtner* emptying near the vaginal orifice.

Structure of the Vagina. — The vagina consists of a mucous coat, of a muscular coat, and of an external coat of erectile tissue.

The *mucous membrane* is of a pale rose color, continuous above with that of the uterus, and below with the integument of the labia majora. It is rough and furrowed, especially near the orifice, and it presents two longitudinal ridges — *columnæ rugarum* — which run, one along the anterior, the other along the posterior wall. From each side of these proceed a series of transverse ridges — *rugæ* — with rough margins directed forwards. They are well marked in virgins, but repeated parturition and increasing age gradually smooth them down. The use of the vaginal rugæ is to excite the sensibility of the glans in coition. They themselves also possess keen sensibility, being richly endowed with papillæ. The mucous membrane is provided with numerous papillæ, conical in shape, and covered with a thick lining of squamous epithelium. In the submucous tissue, which is very loose, there is a good deal of muscular tissue, with a considerable venous plexus, forming a kind of erectile tissue ; in it, also, are found an abundant supply of muciparous glands, which increase in size and number towards the uterus.

The *muscular coat* is arranged in two layers, a longitudinal and a circular, between which there may be demonstrated a number of interlacing fibres passing from one to the other layer. The longitudinal fibres are continuous with the superficial muscular fibres of the uterus, while the latter are chiefly aggregated at the orifice of the vagina, forming a kind of sphincter muscle, which is continuous with the external sphincter ani. Superiorly, the vagina is intimately attached to the neck of the uterus, while to the rectum it is but loosely connected.

The *erectile tissue* found in the connective tissue forms the chief strength of the vagina, being about one-twelfth of an inch in thickness. If this coat be minutely injected, we find that it is composed mainly of a plexus of veins surrounded with numerous fasciculi of unstriped muscular fibres.

Uterus. — The uterus is the hollow muscular organ which receives the ovum, retains it for nine months to bring it to maturity, and then expels it by virtue of its muscular walls. Its situation and peritoneal connections have been described (p. 493). Its axis slants forwards, so that, upon the whole, the axis of the vagina and uterus describes a curve nearly parallel to the axis of the pelvis. The uterus, then, is so situated that it is ready to rise out of the pelvis into the abdomen after the embryo has attained a certain size.

The uterus in the unimpregnated state is pyriform, or rather triangular, with the angles rounded, and is somewhat flattened antero-posteriorly. It is retained in its position by the broad and round ligaments, and measures about three inches (*7.5 cm.*) in length, two (*5 cm.*) in its broadest part, and one inch (*2.5 cm.*) thick in its upper part, and weighs from an ounce (*28⅓ gm.*) to an ounce and a half (*44½ gm.*); but there is a variety in this respect, arising from age, the effect of pregnancy, and other causes.

For convenience of description the uterus is divided into the fundus, the body, and the cervix.

The *fundus* is applied to the broadest part, which lies above the level of the Fallopian tubes, and is completely invested by peritoneum.

The *body* is the central part, and gradually narrows down to the cervix. Its lateral margins are nearly straight, and give attachment, respectively, from above downwards, to the Fallopian tube, the round ligament, the ligament of the ovary, and the broad ligament; its anterior surface is flat, and for full three-fourths of its extent is covered with peritoneum; its posterior surface is convex, and is entirely invested with peritoneum.

The *cervix* is the lower narrow part which projects into the vagina. The vagina is very closely attached round the neck of the uterus; observe that it is attached higher up behind than in front. This turning of the vagina upon the cervix forms the anterior and posterior fornices. At the free end of the cervix there is a transverse slit, the *os uteri*,* bounded in front by the anterior lip, behind by the posterior lip.

* The os uteri in the virgin is circular. — A. H.

Postponing for the present the examination of the interior of the vagina and the uterus, let us pass on to the vessels and nerves of these organs.

Uterine and Vaginal Arteries. — The uterus is supplied by the uterine arteries derived from the internal iliac, and also by the ovarian arteries ; the vagina by the vaginal arteries from the same source ; and the ovaries by the ovarian arteries (which correspond to the spermatic arteries in the male) given off from the abdominal aorta just below the renal arteries.

The *uterine artery* proceeds from the anterior division of the internal iliac, towards the neck of the uterus, between the layers of the broad ligament, and then ascends tortuously by the side of the uterus, giving off numerous branches to it, which anastomose freely with each other, and with a small branch from the ovarian artery. The fundus of the uterus is mainly supplied with branches from the ovarian arteries.

The *vaginal artery* ramifies along the side of the vagina, and distributes branches to the lower part of the bladder and the rectum.

The *veins* of large size, corresponding with the arteries, form the uterine sinuses and the vaginal plexuses, which empty themselves into the internal iliac vein.

Nerves of the Uterus. — The *nerves* of the uterus are derived from the third and fourth sacral nerves, from the hypogastric and ovarian plexuses (p. 488). They accompany the blood-vessels in the broad ligament to the neck of the uterus, and ascend with them along its sides.

Some small filaments continue with the vessels, and form around them plexuses, upon which minute ganglia are found. But most of the nerves soon leave the vessels, and, subdividing, sink into the substance of the uterus, chiefly about its neck and the lower part of its body. A branch may be traced passing up to the fundus of the uterus, and another to the Fallopian tube.

The nerves of the uterus enlarge during pregnancy like the arteries. Surgically speaking, the os uteri may be said to have no nerves, for it is insensible to the cautery and to the knife.

The *lymphatics* of the uterus are small in its unimpregnated state, but greatly increase in size when it is gravid. Those from the fundus and the ovaries proceed with the ovarian vessels to the lumbar glands, thus explaining the affection of these glands in ovarian diseases. Those from the body and the lower part of the uterus accompany the uterine arteries, and join the glands in the pelvis; some, however, run with the round ligament to the groin; hence, in certain conditions of the uterus, the inguinal glands may be affected.

The uterus, vagina, Fallopian tubes, and the ovaries should now be collectively removed from the pelvis for the purpose of examining their internal structure.

Structure of the Uterus. — The structure of the vagina has been already described (p. 546). Before the uterus is laid open, examine the shape of that portion of the neck which projects into the vagina. The back part of the cervix appears to

project into the vagina more than the front; but this arises from the vagina being attached higher up posteriorly. If the vagina were cut away from the cervix, the anterior lip of the uterus would appear to project a trifle more than the posterior. For this reason, as well as on account of the natural slope forwards of the uterus, the front lip is felt first in an examination per vaginam.* The length, however, and the general appearance of the vaginal part of the cervix vary according to the age; it is also considerably altered by parturition. In the adult virgin it is smooth and round, and projects about half an inch (*13 mm.*); its mouth is a small transverse fissure. But after parturition it loses its plumpness, the lips become flaccid and fissured, and the mouth larger than it was before.†

The uterus must now be laid open by a longitudinal incision, to examine its interior. In doing so, observe the thickness of its walls, which is greatest towards the fundus. Before coming into the proper cavity in the body of the uterus, slit up a long, narrow canal which leads up into it through the neck. This canal, which is about an inch (*2.5 cm.*) in length, is not of the same dimensions throughout; it is dilated in the middle, and gradually narrows towards each end. The upper end, which leads into the body of the uterus, is called *os internum;* the lower end, which leads into the vagina, *os externum* (os tincæ). The passage is called the *canal of the cervix.* It remains unchanged in pregnancy for some time after the cavity in the body has expanded, but gradually disappears with the increasing size of the embryo.

The shape of the *cavity* in the body of the uterus is triangular, with the apex towards the cervix. In a virgin uterus the cavity is very small, and its sides are convex; but in a uterus which has borne many children, the cavity has lost the convexity of its sides, and has increased in capacity. Each angle at the base is

* This is the only way to reconcile the discrepancies one meets with in anatomical works respecting the comparative length of the lips of the uterus. Krause, Weber, Busch, and others, say the anterior is the longer; Mayer, Meckel, Quain, and others, the posterior.

† Instances are recorded in which the neck of the uterus is preternaturally long. It has been known to project even as much as an inch and a half (*3.8 cm.*) into the vagina. In such cases it gradually tapers, and terminates in a very narrow mouth. This is said to be one cause of sterility, and it is recommended either to dilate the mouth, or to cut off a portion of the neck. In support of this opinion, it is stated that Dupuytren was once consulted by a lady on account of barrenness; finding the neck of the uterus unusually elongated, he removed a portion of it, and shortly the lady became pregnant. (Hyrtl, *Handbuch der top. Anatom.*)

somewhat prolonged, and leads to the minute opening of the Fallopian tube. This prolongation of the angles is noticed more or less in different females, and is the last indication of the two horns of the uterus in some orders of mammalia.

The interior of the uterus is smooth at the fundus, but the reverse at the cervix. Here there is a central longitudinal ridge, both in front and behind (as in the vagina); from these, other closely set oblique ridges curve off laterally, like the branches of a palm-tree, called *arbor vitæ uterina.* The roughness produced by these ridges occasions an impression as though we were touching cartilage when a sound is introduced into the uterus.

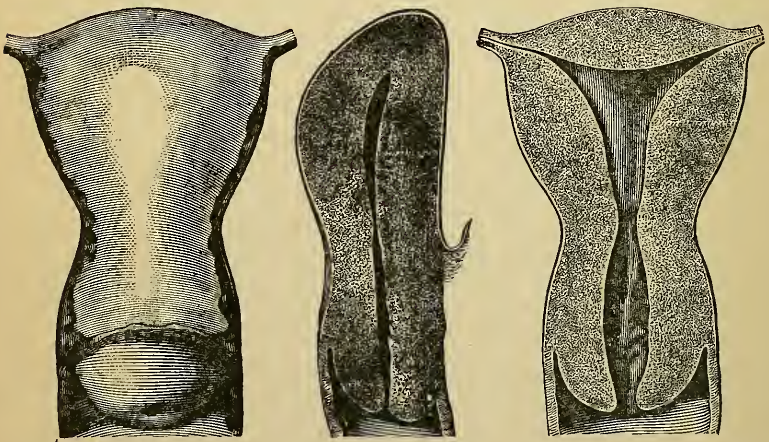


FIG. 199.—VIRGIN UTERUS.
A. Anterior view. B. Median section. C. Lateral section.

The *neck* of the uterus is provided with small muciparous glands, of which the minute ducts open in the furrows between the ridges referred to. The secretion of these glands is glairy, albuminous, and slightly alkaline. Soon after impregnation the secretion becomes so firm as to plug the mouth of the uterus; but shortly before and during parturition it is poured out in great quantity, to facilitate the passage of the child. It happens occasionally that one or more of the ducts of these glands becomes obstructed, and then dilate into small transparent vesicles, which gradually rise to the surface and burst.*

* These were first described by Naboth, and supposed to be true ova; hence their name, *ovula Nabothi.* (*De Sterilitate Mulierum.* Lips., 1707.)

The walls of the uterus consist of an outer serous coat derived from the peritoneum, an inner mucous lining, and an intermediate layer of unstriped muscular tissue.

The *serous coat* has been already described.

The *muscular coat* forms the greater part of the thickness of the walls of the uterus, and consists of non-striped or involuntary muscular fibres, chiefly aggregated at the fundus, less so at the junction of the Fallopian tubes. The texture of these fibres is very close, and interwoven together with blood-vessels, nerves, lymphatics, and connective tissue; so that in the unimpregnated uterus it is almost impossible to trace them. In the impregnated condition it is less difficult to trace them, and we can make out that the fibres are arranged in three layers — an external, a middle, and an internal.*

The *external layer*, placed immediately beneath the peritoneum, is thin, and its fibres, beginning as longitudinal at the cervix, run transversely round the uterus, some of them being continued in an oblique direction over the body into the broad ligaments; these are continued on to the Fallopian tubes, the round ligaments, and the ligaments of the ovaries. A band of longitudinal fibres passes from the anterior surface of the uterus round the fundus to its posterior aspect, beneath the recto-uterine folds of the peritoneum.

The *middle layer* runs in all directions, having no definite arrangement of its fibres.

The *internal layer* is composed mainly of concentric circles which surround the orifices of the Fallopian tubes; at the cervix its fibres are arranged transversely, forming a sphincter. It is this layer which forms the thickest stratum and is closely connected with the mucous membrane; it is called the muscularis mucosa.

Upon the whole, the collective disposition of the muscular layers is such as to exert equal pressure on all sides when called into action. At the same time that they expel the fœtus, the muscular fibres perform another very important function: they close the large venous sinuses consequent upon the great increase in the amount of blood during pregnancy. Therefore, little hæmorrhage accompanies the expulsion of the placenta, provided it have been attached to the fundus or the side of the uterus. But every one knows the danger of what is called *placenta prævia.* Here, the placenta, placed entirely or partly over the orifice of the uterus, is attached to a part of the organ which must of necessity expand during labor, and every uterine contraction increases, instead of checking, the bleeding. For the same reason, paralysis of the muscular fibres in imme-

* In the unimpregnated uterus the muscular fibres are about $\frac{1}{100}$ of an inch in length; in the gravid uterus they increase to $\frac{1}{40}$ of an inch.

diate connection with the placenta, be it where it may, is likely to be a source of serious hæmorrhage in parturition.

The *mucous membrane* of the uterus is more delicate and softer than that of the vagina, with which it is continuous, and is closely united to the subjacent tissue. The greater part of it is lined by a columnar ciliated epithelium, but that which lines the lower part of the cervix is squamous, like that of the vagina. Examined with a lens, the mucous membrane lining the body of the uterus is seen to be covered with minute follicles or tubes (*uterine glands*) arranged at right angles to its surface. These tubes pass outwards in a more or less spiral manner, some of them appearing branched and dilated at their extremities. They become greatly developed shortly after impregnation, and take an important part in the formation of the *membrana decidua.*

The arrangement of the mucous membrane in the cervix has been already described (p. 549) when the uterus was laid open to expose its cavity.

Fallopian Tubes. — The *Fallopian tubes* or *oviducts* are situated, one on each side, along the upper free border of, and enclosed by, the broad ligament of the uterus, and convey the

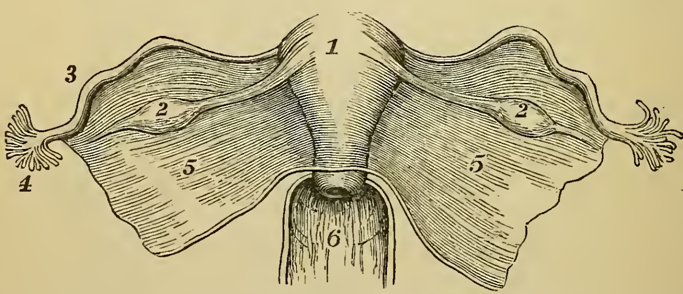


Fig. 200. — Diagram of the Uterus, its Broad Ligaments, the Ovaries, and Fallopian Tubes. (Seen from Behind.)

1. Uterus. 2. Ovary, with its ligaments. 3. Fallopian tube. 4. Fimbriated extremity of Fallopian tube. 5, 5. Broad ligament. 6. Vagina.

ovum from the ovary to the uterus (Fig. 200). They are about four inches (*10 cm.*) in length: one end, the *ostium internum*, opens by a minute orifice into the upper angle of the cavity of the uterus; the other terminates in a wide, funnel-shaped mouth, the *ostium abdominale*, surrounded by fringe-like processes called the *fimbriæ.* This termination of the Fallopian tube is called its fimbriated *extremity*,* and its canal opens into the peritoneal cavity, so that thus the cavity of the peritoneum in the female communicates through the uterus and the vagina indirectly with the exterior. The fimbriated extremity extends about an inch (*2.5 cm.*) beyond the ovary, and, by floating it in

* The fimbriated extremity is sometimes called the *morsus diaboli*, since it embraces in a peculiar way the ovary during sexual excitement.

water, one or two of the fimbriæ may be seen connected with the outer end of the ovary (tubo-ovarian ligament or fimbria ovarica) and are much longer than the free fimbria. If the Fallopian tube be opened from the dilated end, and a probe introduced into it, you will find that the tube runs very tortuously at first, then straight into the uterus, gradually contracting in size, so that the uterine orifice scarcely admits a bristle. The free end of the tube or *ampulla* communicates with the cavity of the peritoneum. This is the only instance where a mucous membrane is directly continuous with a serous one. It explains how the embryo may escape into the peritoneal cavity, though this is an extremely rare occurrence. It also explains what is said to have occurred, namely, the escape of the fluid in dropsy through the Fallopian tubes. In a well-injected subject, the Fallopian tubes are seen to be well supplied with blood from the ovarian arteries.

The coats of the Fallopian tube are three — an *external serous coat*, derived from the peritoneum; * a *middle muscular* coat, consisting of plain muscular fibres: an external layer, longitudinal, and an internal layer, circular, both being continuous with those of the uterus; and an *internal mucous coat* arranged in longitudinal folds, especially at the ovarian end, and covered with a columnar ciliated epithelium.

Ovaries. — The *ovaries* (called by Galen, *testes muliebres*, being the analogues of the testes in the male) are two oval bodies situated between the two layers of the broad ligament of the uterus, in its posterior part. They are connected on their inner side to the uterus by a thin cord, called the *ligament of the ovary*, and at their outer end they are usually attached to one of the fimbriæ of the Fallopian tube by fibrous tissue, *the tubo-ovarian ligament.* The ovaries are of whitish color, with the long axis transverse, flattened from above downwards; and in females who have not often menstruated their surface is smooth and even; in after-life they become puckered and scarred by the repeated escape of the ova.

The position of the ovaries is described by Professor His as being nearly vertical, and he states that the Fallopian tube curves round the outer to the lower border of the ovary, so that the fimbriated extremity lies beneath the ovary, with its fimbriæ directed upwards; thus the ova on their escape from the ovary fall into the Fallopian tube.†

* Some authorities speak of a *cellular* coat between the serous and muscular coats, composed of subperitoneal tissue and rich in blood-vessels. — A. H.

† His, "Lage der Eierstöcke," *Archiv. f. Anat.*, 1881.

The ovary is about an inch and a half (*3.8 cm.*) long, three-quarters of an inch (*18 mm.*) wide, and about half an inch (*13 mm.*) thick; its weight being from one to two drachms (*4 to 8 gm.*). It consists of a dense soft stroma, imbedded in which are numerous small vesicles (*Graafian vesicles*), muscular tissue, blood-vessels, and nerves, the organ being invested by a serous covering.

The *serous layer* covers the ovary, but does not present the ordinary features of a peritoneal investment, for the covering is dull and not shining, and the epithelium consists of a single layer of columnar cells which are the remains of the germ epithelium, from which the ova and the other cells in the Graafian vesicles have been originally developed.*

The *stroma* composes the substance of the ovary, and consists of some connective tissue associated with a large amount of spindle-shaped cells, resembling in their appearance unstriped muscle-cells. It contains also elastic tissue, and is abundantly supplied with blood-vessels, which are larger at the hilum of the ovary, diminishing in size towards its surface. The outer part of the stroma is much condensed, so as to give a white appearance to the organ; this has been described as a proper fibrous coat, the *tunica albuginea ovarii*, but which does not actually exist as a separate layer.

If a section be made through the ovary, you will find that imbedded in the stroma are a large number of small transparent vesicles, which are more abundant at the circumference of the ovary, while in the central part there are comparatively few, it being composed almost entirely of the stroma.

The transparent vesicles just alluded to are the *Graafian follicles*, or the ovisacs, which contain the ova.† In the outer part or cortical layer of the stroma of the ovary may be observed a large number of closely set minute vesicles, about $\frac{1}{100}$ of an inch (*0.2 mm.*) in diameter, more numerous in the ovaries of young children and in some animals. In the central part or medullary portion of the stroma are seen larger and less numerous vesicles, the largest being placed most deeply; but these, as they become mature, gradually make their way towards the surface, probably by absorption, and when fully developed measure from $\frac{1}{20}$ to $\frac{1}{6}$ of an inch (*1.5 to 4 mm.*) in diameter.

* Waldeyer, *Eierstock u. Ei*, Leipzig, 1870; and in Stricker's *Handbuch*, 1871.

† So called after De Graaf, a Dutch anatomist, who discovered them in 1672, and believed they were the true ova.

One, or perhaps more than one, Graafian vesicle ruptures at each menstrual period, and the little ovum it contains escapes from the vesicle, and is either grasped by, or falls into the fimbriated end of the Fallopian tube, and is thus conveyed into the uterus. The ruptured vesicle from which the ovum has escaped becomes filled with blood, and subsequently also with an exudation from its walls, so as to constitute a reddish-yellow substance, called the *corpus luteum*, which persists for a while and then degenerates into a small stellate fibrous cicatrix.

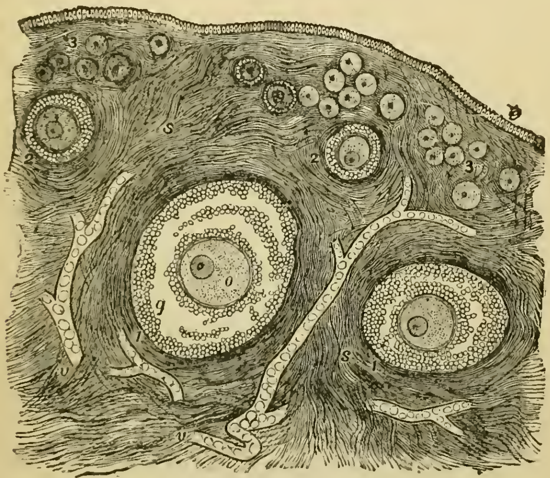


FIG. 201. — SECTION OF AN OVARY.

e Germ epithelium. 1. Large-sized follicles. 2, 2, Middle-sized, and 3, 3, smaller-sized follicles *o*. Ovum within a Graafian follicle. *v*, *v*. Blood-vessels of the stroma. *g*. Cells of the membrana granulosa.

The Graafian vesicles are very numerous, especially in the young subject, the smaller ones being the most numerous, their average diameter being about $\frac{1}{100}$ of an inch (*0.2 mm*).* External to the larger vesicles there can be distinguished a *membrana propria* or basement membrane; internal to this, the stroma becomes altered so as to constitute a distinct wall to the follicle. Within this, and lining the wall of the vesicle, there is a layer of nucleated cells, called the *membrana granulosa*, which surrounds a transparent albuminous fluid in which the *ovum* or *germ* is contained. The vesicle, as it approaches

* It has been computed that in the ovaries of a child at birth there are no less than 70,000 Graafian follicles.

the surface of the ovary, develops an additional layer of granular cells, called the *discus proligerus*, within which the ovum is imbedded, lying usually towards the free surface of the ovary.

The ramifications of the *ovarian artery* through the ovary are remarkable for their convolutions; they run in parallel lines, as in the testicle. Its *nerves* are derived from the ovarian plexus, which comes from the renal. The *ovarian veins* form, like the spermatic veins, near the ovary, the pampiniform plexus, and then terminate, the right in the inferior vena cava, the left in the renal vein.

Parovarium.—The *parovarium*, or the *organ of Rosenmüller*, is the remains of a fœtal structure situated in the broad ligament, between the Fallopian tube and the ovary. It consists of a series of convoluted closed tubules, lined with epithelium, converging from beneath the Fallopian tube to the ovary. At their ovarian end the tubules are separate, but at their broader end they are joined by a longitudinal tube running parallel to the lower border of the Fallopian tube. It is the vestige of a fœtal structure, and is the analogue of the epididymis in the male, and is connected at its uterine end with the remains of the Wolffian duct.

DISSECTION OF THE ABDOMINAL VISCERA.

The Liver. — The liver is the largest glandular organ in the body, and in the adult weighs from fifty to sixty ounces (*1550 to 1860 gm.*). It serves for the secretion of the bile, and, moreover, alters some of the constituents of the blood in its passage through the organ. Its bilateral diameter is from ten to twelve inches (*25 to 30 cm.*); from before backwards (*dorso-ventrally*) it measures from six to seven inches (*15 to 17.5 cm.*); and its greatest (*cephalo-caudad*) thickness, which is at its back, is about three inches (*7.5 cm.*).

Topography. — The liver is situated in the right hypochondriac epigastric and may extend into the left hypochondriac regions. It is below the diaphragm, in front of the ninth, tenth, and eleventh thoracic vertebræ, and on the right side is placed between the seventh and eleventh ribs; in front it is placed behind the fifth, sixth, seventh, eighth and ninth costal cartilages; its anterior border can be outlined on the right side by the margins of the costal cartilages; on the left side this border is in contact with the anterior abdominal wall below the appendix sterni. The liver is movable in the abdominal cavity,

and changes its position with that of the body; it is depressed in deep inspiration; it is elevated in the dorsal decubitus one inch (*2.5 cm.*) above the costal margins. In children the liver is much larger in proportion to the body-weight than in the

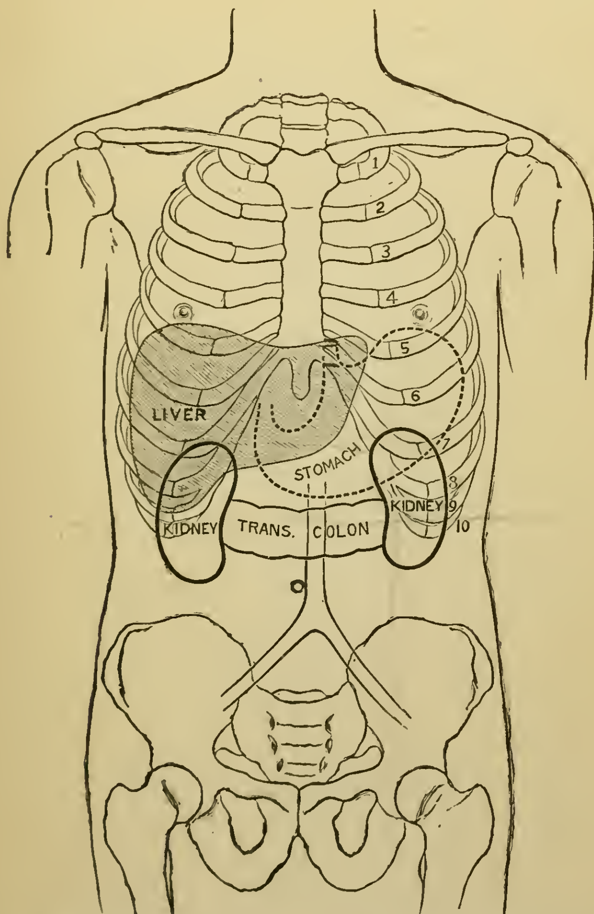


FIG. 202.—RELATION OF THE ABDOMINAL VISCERA TO THE PARIETES. (*Treves.*)

adult. The extreme left point of the liver is about one and one-half inches (*3.8 cm.*) to the left of the sternum; ventrally, in the mesial line, it extends midway between the xiphoid and the umbilicus. It crosses the epigastrium on a line drawn

from the ninth right to the eighth left costal cartilages (Quain). The upper limit of the liver is indicated by a line drawn horizontally to the left extreme point of the organ; but rising

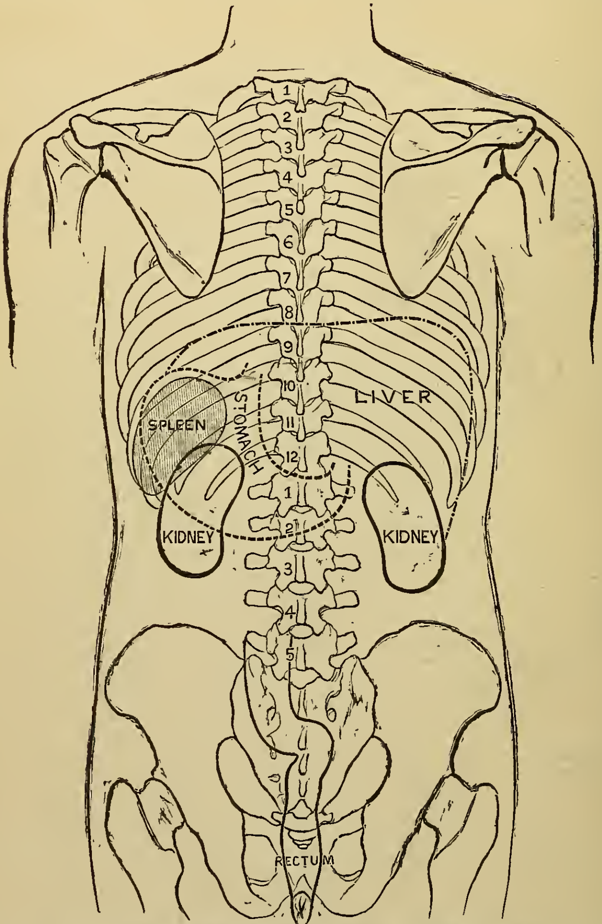


FIG. 203. — RELATION OF THE ABDOMINAL VISCERA TO THE PARIETES. (*Treves.*)

on the right to the fifth rib in the mammary line, and from the point to the spine of the tenth or eleventh thoracic vertebræ.

Its surface is entirely covered with peritoneum, except a small part behind, which is connected to the diaphragm and

the upper part of the right kidney by cellular tissue, and again in the hollow which lodges the gall-bladder.

The *upper surface* is smooth and convex in adaptation to the diaphragm, and is marked by a fold of peritoneum running from behind forwards, dividing this surface into two unequal lobes, a right and a left, the right being the larger. The fold of peritoneum is the *suspensory* or *broad ligament.*

The *under surface* is concave and irregular, and is divided into a right and left lobe by the longitudinal fissure, and extends backward to and including the transverse fissure, and is covered by peritoneum.

The *posterior surface* is concave from its contact with the vertebral column, and extends from the upper portion of the coronary ligament to the posterior margin of the transverse fissure. It contains a small portion of the left lobe, with its tuber omentale, not well defined, except in hardened specimens; the Spigelian lobe, the caudate lobe, a portion of the right lobe embraced between the folds of the coronary ligament, and the vena cava.*

The *posterior border* is thick and round, having attached to it the *coronary ligament.*

The *anterior border* is thin and sharp, and presents a notch indicating the division into a right and left lobe; the notch lodges the round ligament, which is the remains of a fœtal structure, the umbilical vein. There is also to the right side of the notch a slight groove corresponding to the base of the gall-bladder.

The *right border* is thick and round, the *left* is flat and thin.

Fissures. — The under surface is irregular, and is marked by five fissures which map out the five lobes (Fig. 204). They are the longitudinal fissure, the fissure for the ductus venosus, the fissure for the gall-bladder, the fissure for the inferior vena cava, and the transverse fissure. The relative position of these fissures (the liver being *in situ*) may be best impressed on the memory by comparing them collectively to the letter H. The transverse fissure represents the cross-bar of the letter; the longitudinal fissure and the fissure for the ductus venosus represent the left bar; the fissures for the gall-bladder and the vena cava make the right bar.

* To develop all the depressions and elevations the subject should be injected with a hardening preservative substance containing 3% to 5% of formaldehyde. — A. H.

The *longitudinal fissure* divides the right from the left lobe, and contains the round ligament, which is the remains of the umbilical vein in the fœtus. It is deeper in front than behind, and is not infrequently bridged over by liver tissue, constituting the *pons hepatis*.

The *fissure for the ductus venosus* is the continuation backwards of the longitudinal fissure to the posterior border of the liver, and contains a fibrous cord, which is the obliterated remains of what was in the fœtus the ductus venosus.

The *fissure for the gall-bladder* is a shallow depression to the right of the longitudinal fissure, and lodges the gall-bladder.

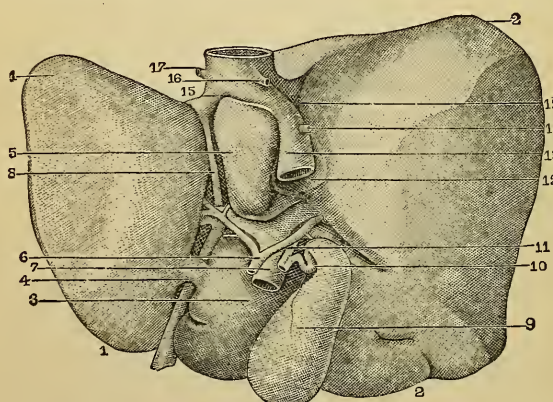


Fig. 204.—Under Surface of the Liver.

1. Left lobe. 2. Right lobe. 3. Lobulus quadratus. 4. Pons hepatis. 5. Lobulus Spigelii. 6. Hepatic artery. 7. Portal vein. 8. Obliterated ductus venosus. 9. Gall-bladder. 10. Cystic duct. 11. Hepatic duct. 12, 12. Fissure for the vena cava. 13. Inferior vena cava. 14. Vein to the capsule of the liver. 15. Left hepatic vein. 16. Right diaphragmatic vein. 17. Left diaphragmatic vein.

The *fissure for the inferior vena cava* runs obliquely backwards and joins at an acute angle the fissure for the ductus venosus at the posterior border of the liver. It begins close to the right extremity of the transverse fissure, and is not uncommonly surrounded by hepatic tissue.

The *transverse* or *portal fissure*, about two inches (*5 cm.*) in length, unites the other fissures, and transmits the large vessels which enter the liver in the following order: in front is the hepatic duct, behind is the vena portæ, and between them the hepatic artery.

The lobes of the liver, five in number, are also seen on its ventral and dorsal surfaces.

Lobes. — The *right lobe*, much larger than the left, is separated from it by the longitudinal fissure on its ventral aspect, and by the falciform ligament on its cephalad surface. Its cephalad surface is smooth and convex, somewhat quadrilateral in shape; on the ventral surface it is marked by three fissures — the transverse, and those for the gall-bladder and vena cava. It has also on its ventral surface two shallow fossæ: the anterior (*impressio colica*) is for the hepatic flexure of the colon; the posterior (*impressio renalis*) for the right kidney and the supra-renal capsule.

The *left lobe* is the smaller; its cephalad surface is smooth and convex, its ventral is concave and rests on the stomach.

The remaining lobes may be considered as forming parts of the right lobe, and are the lobulus Spigelii, the lobulus caudatus, and the lobulus quadratus.

The *lobulus Spigelii* is a prominent quadrilateral lobe, placed between the transverse fissure and the fissures for the ductus venosus and vena cava; dorsad to the transverse fissure it is connected to the right by a ridge, the lobulus caudatus.

The *lobulus caudatus*, which passes obliquely ventrally and to the right, separating the fissure for the vena cava from the transverse fissure.

The *lobulus quadratus* is a square lobe situated between the gall-bladder, the longitudinal and the transverse fissures. This lobe is occasionally connected to the left lobe by a bridge of hepatic substance arching over the longitudinal fissure, and alluded to before as the pons hepatis.

Ligaments. — The liver has five ligaments, of which the *coronary*, the *right* and *left lateral*, and the *falciform* are reflections of the peritoneum; the fifth is the *round ligament*, placed in the ventral free border of the falciform ligament in the longitudinal fissure; it consists of the remains of the umbilical vein of the fœtus. The ligaments have already been described (p. 451).

Vessels. — The vessels which pass to and from the liver are five also in number: the hepatic artery, the vena portæ, the hepatic veins, the hepatic duct, and the lymphatics. The consideration of these is deferred till we have examined the capsule of the liver.

The *fibrous coat* surrounds the liver, and is best seen on those parts of it not covered with peritoneum. This coat is connected on the surface of the gland to the areolar tissue which surrounds the lobules, but does not send down partitions to form a frame-

work for the interior. It is continuous, at the transverse fissure, with the sheath of loose areolar tissue, called *Glisson's capsule*, which surrounds the vessels as they enter that fissure, and encloses them in a common sheath in their ramifications through the liver.

The interlobular connective tissue is exceedingly delicate: hence the great liability of the liver to be lacerated by external violence, and consequent hæmorrhage into the peritoneal cavity.

Lobules. — The liver consists of an aggregation of small polyhedral masses, called *lobules*, about the size of a millet seed, which range from $\frac{1}{24}$ to $\frac{1}{12}$ of an inch (*1 to 2 mm.*) in diameter. These lobules are more or less distinctly marked out by septa of areolar tissue, and in a transverse section have the appearance of mosaic pavement (Fig. 205); but in a perpendicular section they somewhat resemble an oak leaf (Fig. 206). Each lobule is mapped out by, and separated from, the adjacent lobules by delicate connective tissue, in which runs a plexus of vessels — *interlobular plexus* — consisting of branches of the portal vein. From this plexus passes inwards into the lobule a fine capillary network, whose branches converge to the centre of the lobule and end in a single vein, the *intralobular vein*, which, in its turn, opens into the *sublobular vein*, and thence into the *hepatic vein*. With the interlobular plexus run the biliary ducts. The lobules themselves consist of a minute plexus of blood-vessels, ducts, and cells — *hepatic cells* — which latter fill up the spaces between the ramifications of the vessels. It will facilitate the understanding of the different hepatic vessels, if it be borne in mind, (1) that the portal vein, hepatic artery, and hepatic duct ramify together from first to last, enclosed in a common sheath of connective tissue, called *Glisson's capsule*; (2) that the hepatic veins run alone from first to last, and terminate in the inferior vena cava as it passes through the posterior or dorsal surface of the liver.

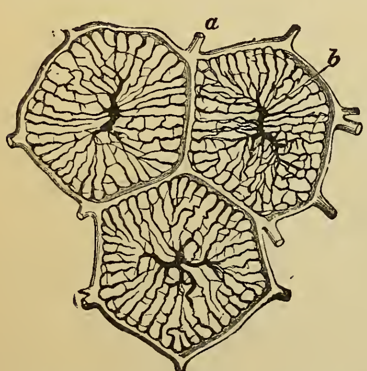


FIG. 205. — TRANSVERSE SECTIONS OF THREE LOBULES OF THE LIVER, MAGNIFIED TO SHOW THE PORTAL VENOUS PLEXUS. (*After Kiernan.*)
a. Interlobular vein. *b.* Intralobular or central vein.

The *portal vein* enters the transverse fissure of the liver, accompanied by the entering hepatic artery and the emerging right and left hepatic ducts, which, as before stated, are surrounded in the liver by a common sheath called Glisson's capsule. In the liver the portal vein ramifies between the lobules and gives off numerous branches, called *interlobular* or peripheral veins, which pass between the lobules and communicate freely with each other. These receive the *vaginal* and *capsular veins* which convey the blood from the corresponding branches of the hepatic artery. The interlobular plexus of veins gives off a minute capillary network, which penetrates into the interior of the lobule, and converges towards the centre of the lobule to open directly into a single central vein called the *intralobular vein.* The capillaries which compose this network run in a nearly parallel direction from the circumference to the centre of the lobule, and communicate freely with each other by small transverse branches. The intervals between the branches of the capillary network is very small, varying from $\frac{1}{1000}$ to $\frac{1}{450}$ of an inch, while the vessels themselves are comparatively large, being about $\frac{1}{2500}$ of an inch in diameter. The intralobular vein returns the blood from the centre of the lobule, and opens immediately into a *sublobular vein*, larger or smaller as the case may be, upon which the lobule is sessile (Fig. 206).

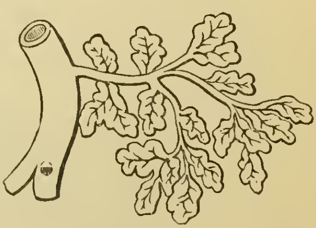


Fig. 206. — Longitudinal Sections of the Lobules of the Liver. Intralobular Veins seen Joining the Sublobular.

The sublobular veins, increasing in size, empty themselves into the smaller *hepatic veins;* these unite to form the main hepatic trunks, usually three in number, one each from the right and left lobes and the lobulus Spigelii. These hepatic veins open into the inferior vena cava as this vessel passes to the posterior border of the liver.

The *hepatic artery*, entering the transverse fissure of the liver, divides and subdivides with the portal vein and biliary ducts, and ramifies with them between the lobules. The artery distributes branches — *vaginal branches* — whilst within the portal canals which supply the coats of the hepatic vessels and Glisson's capsule; also *capsular branches* to the fibrous coat of the liver, which appear on the surface of the liver in stellate plexuses; and *interlobular branches,* which accompany the corresponding veins and

pass into the lobules to join the capillary network which leads to the radicles of the intralobular vein.

The interior of each lobule — that is, the space left between the several vessels — is filled by the *hepatic cells*. They are of spheroidal or polyhedral shape, with a diameter varying from

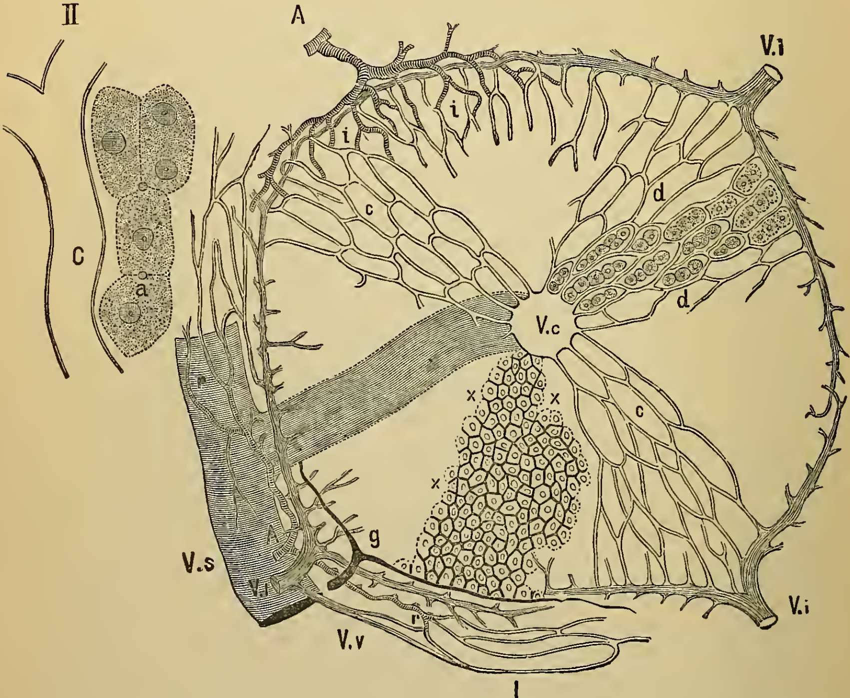


FIG. 207. — I. DIAGRAM OF A LIVER LOBULE.

V.i, Vi. Interlobular vein (portal). V.c. Central or intralobular vein (hepatic). c,c. Capillaries between both. V.s. Sublobular vein. V.v. Vena vascularis. A.A. Hepatic artery, giving branch r,r, to Glisson's capsule and the larger vessels, and ultimately forming the venæ vasculares at i,i, opening into the intralobular capillaries. g. Bile ducts. x,x. Intralobular biliary channels between the liver cells. d,d. Position of the liver cells between the meshes of the blood capillaries.
II. ISOLATED LIVER CELLS. — C. Blood capillaries. a. Fine bile-capillary channel.

$\frac{1}{1100}$ to $\frac{1}{850}$ of an inch, and have no cell-wall. They consist of a granular substance of a light yellow tinge, containing one or more distinct nuclei having a highly refracting nucleolus. In some cases the cells contain fat globules; when these accumulate in large quantities, they constitute what is called a fatty liver. The office of the hepatic cells is to separate the bile from

the blood, and when filled with bile, to discharge their contents into the biliary ducts.

The *biliary ducts* are the channels through which the bile is conveyed into the hepatic ducts. They commence as minute passages — *bile canaliculi* — which are formed between and around the hepatic cells, and then pass outwards to the circumference of the lobule, where they open into the bile-ducts between the lobules.* Here they form a plexus — *interlobular* — which opens into ducts which run with the hepatic artery and portal vein in the portal canals; eventually these join with other ducts to form the right and left hepatic ducts, which leave the transverse fissure of the liver, and, after a course of about an inch, unite to form a single duct, the *common hepatic duct.*

The *lymphatics* of the liver are arranged in two sets: superficial and deep. The *superficial* may be divided into those on the cephalad convex surface and those on the ventral aspect; the lymphatics on the convex surface are: (1) those which run dorsally between the layers of the falciform ligament and then pass through the diaphragm dorsad to the ensiform cartilage to enter the anterior mediastinal glands, and thence to the right lymphatic duct; (2) those which pass ventrally over its ventral margin to the ventral aspect to enter the glands in the gastrohepatic omentum; (3) those which run to the right lateral ligament, and then either pierce the diaphragm to join the anterior mediastinal glands, or pass inwards to open into the thoracic duct at its commencement; and (4) those which run to the left lateral ligament, which, after piercing the diaphragm, open into the anterior mediastinal glands. The lymphatics on the under aspect are arranged as follows: (1) those on the right side of the gall-bladder open into the lumbar glands; (2) those surrounding the gall-bladder accompany the hepatic artery to join the glands in the gastro-hepatic omentum; (3) those on the left side enter the glands on the lesser curve of the stomach and the œsophagus. The *deep lymphatics* originate partly in the connective tissue between the lobules, and there accompany the hepatic artery and portal vein and duct to the transverse fissure, to join the lymphatic glands on the lesser curve of the stomach and dorsad to the pancreas; some lymphatics also accompany the branches of the hepatic veins.

The *nerves* of the liver are derived from the pneumogastric, chiefly the left, and from the hepatic plexus which comes from the cœliac plexus. These plexuses enter the liver at the transverse fissure, surround the hepatic artery and the portal vein, and accompany these vessels in their ramifications through it. The ultimate termination of these nerves is not known.

The *functions* of the liver may be thus briefly expressed: 1. It renders the albuminous matter (albuminose), brought to it by the portal vein, capable of being assimilated. 2. It forms a substance, *glycogen*, easily converted into sugar, which passes into the hepatic veins, and, being consumed, helps to maintain animal heat. 3. It secretes the bile, which assists in convert-

* The biliary ducts between the lobules are lined with a short columnar epithelium, resting on a basement membrane; but it is doubtful whether the bile-canaliculi are very minute ducts, or whether they are not simple intercellular passages between the hepatic cells.

ing the chyme into chyle, and reducing it into a state fit to be absorbed by the lacteals. 4. The bile acts as a natural aperient. 5. The bile is an antiseptic, and probably prevents the decomposition of the food during its passage through the intestine.

Gall-bladder. — The gall-bladder, or reservoir for the bile, is pyriform in shape, and is confined in a slight depression on the under surface of the right lobe of the liver (p. 452). It is about four inches (*10 cm.*) long, an inch (*2.5 cm.*) in its broadest part, and is capable of holding about 1½ oz. (*49.2 c.c.*) of fluid. Its broadest part projects beyond the ventral margin of the liver, and it is maintained in its position by the peritoneum, which usually is continued over it from the liver, but which may occasionally completely invest it, so as to form a kind of mesentery. It is divided into a fundus, a body and a neck. The *fundus* is its broadest part, and usually projects a little beyond the ventral border of the liver; from this it gradually narrows, forming the *body*; and this again still further contracts to form the *neck*, which makes a bend downwards, curving upon itself like the letter S. The neck terminates in a duct called the *cystic duct*, which, after a course of about an inch (*2.5 cm.*), joins the common hepatic duct at an acute angle. The common duct thus formed, called the *ductus communis choledochus*, is about three inches (*7.5 cm.*) long, and of the size of a crow-quill; it opens into the inner side of the back of the descending part of the duodenum, after running very obliquely through the coats of the bowel.

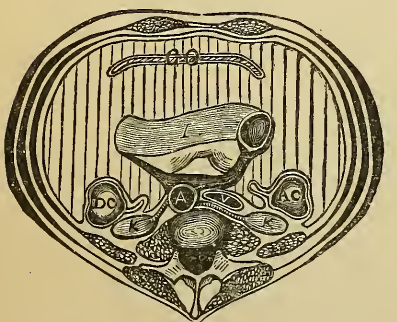


Fig. 208. — Diagram of a Transverse Section through the Lower Part of the Abdominal Cavity.

G.O. The great omentum with its cavity. I. Small intestine. A. Aorta. V. Inferior vena cava. A.C. Ascending colon. D.C. Descending colon. K. Kidneys.

The gall-bladder consists of two coats, and of a partial peritoneal covering which only completely surrounds the fundus.

The *middle coat* consists of strong connective tissue, whose fibres interlace in all directions, and in which involuntary muscular fibres can be traced, running mainly in the long axis of the gall-bladder.

The *mucous coat* can only be seen when the gall-bladder has been opened, which should now be done by laying it open from the fundus to the neck. It is loosely connected to the middle coat, and it is gathered into ridges, which give it a honeycombed appearance, more or less tinged yellowish-brown by the bile. This appearance is most marked in the middle of the gall-bladder, where the surface is covered with polygonal ridges enclosing depressions, in which may be seen with a lens numerous openings leading down to mucous follicles. It is covered with columnar epithelium, which secretes an abundance of viscid mucus. At the bend of the neck of the gall-bladder both its coats project very much into the interior, making the opening considerably narrower than it appears to be outside. In the cystic duct the mucous membrane presents a series of folds, so arranged one after the other as to form a complete spiral valve. The probable use of this is to prevent the too rapid flow of the bile. The gall-bladder appears to serve mainly as a reservoir for the bile while digestion is not going on. The bile becomes during its sojourn in the gall-bladder very viscid and intensely bitter.

The gall-bladder is supplied with blood from the cystic branch of the right hepatic artery; its blood is returned by the cystic vein, which opens into the vena portæ; its nerves are derived from the cœliac plexus, which accompany the hepatic artery.

Pancreas. — The *pancreas* is a large gland belonging to the acino-tubular class. It is placed transversely across the dorsal wall of the abdomen in the epigastric and left hypochondriac regions on the body of the first lumbar vertebra, and measures from six to eight inches (*15 to 20 cm.*) in length, about an inch and a half (*3.8 cm.*) in breadth, and from half an inch to an inch (*13 mm. to 2.5 cm.*) in thickness, its weight being usually from two to three and a half ounces (*62 to 108 gm.*).*

It presents for examination a head, a body, and a tail.

The *head*, situated to the right side, is turned down, and is embraced by the descending and transverse portions of the duodenum, the superior and inferior pancreatico-duodenal arteries running between them. A considerable prolongation usually extends upwards from the posterior part of the gland, and reaches the lesser curve of the stomach; this constitutes sometimes a separate mass, and is then termed the *lesser pancreas*.

* It is of a soft structure and a pinkish-cream color. — A. H.

The *tail* is the narrow end of the pancreas, which extends to the left as far as the hilum of the spleen.

The *body* is convex in front, and is covered by the ascending layer of the transverse meso-colon.

The pancreas has a *posterior surface* which is concave, and lies on the vena cava, the aorta, the crura of the diaphragm, the superior mesenteric artery and vein, the commencement of the vena portæ, and the inferior mesenteric vein; an *upper border* which is thick, and is in relation with the splenic artery and vein, the cœliac axis, the hepatic artery, and the first portion of the

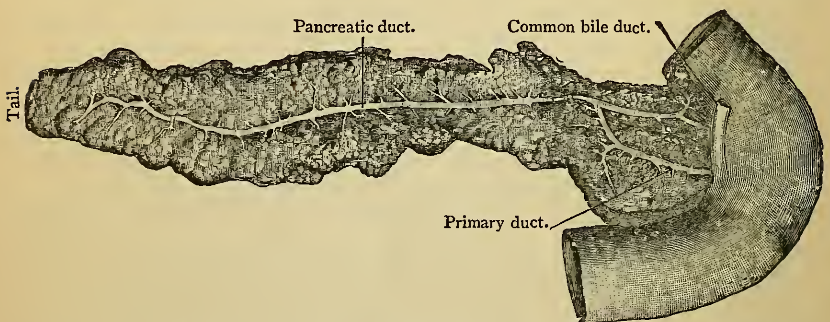


FIG. 209.—PANCREAS AND DUODENUM SEEN FROM BEHIND. THE GLAND IS CUT TO SHOW THE DUCT.

duodenum; and a *lower border* which is thin, and is in relation with the superior mesenteric artery and vein, and on its left with the inferior mesenteric vein.

The *duct of the pancreas*, called also the *duct of Wirsung*, passes from left to right in the pancreas, nearer its lower than its upper border, and nearer its anterior or ventral than its posterior or dorsal surface. Commencing at the tail by the junction of the smaller ducts, it receives in its course to the right side, repeatedly, other ducts, and thus gradually increases in size until it reaches the head, where it usually receives a large branch from the lesser pancreas; the large duct then curves downwards, and comes into relation with the common bile duct; it then passes very obliquely through the coats of the descending duodenum on its posterior aspect, and then either opens separately, or in conjunction with the common bile duct, into this portion of the intestine.

The *structure* of the pancreas resembles in most of its char-

acters that of the salivary glands. The alveoli are tubular, frequently convoluted, and are lined by columnar epithelium, which leaves only a narrow lumen, which is often occupied by spindle-shaped cells called the *centro-acinar-cells*.* The ducts are very constricted at their commencement from the alveolus, and are lined by short columnar epithelial cells, which become larger towards the termination of the duct.

The *arteries* of the pancreas are derived from the splenic, the superior and inferior pancreatico-duodenal branches, respectively, of the hepatic and the superior mesenteric arteries. The veins open into the splenic and superior mesenteric veins. The *lymphatics* end in the lumbar glands; its *nerves* are derived from the solar plexus.

The *uses* of the pancreatic fluid are: to convert the starchy matters into dextrine and grape sugar; to emulsify (in conjunction with the bile) the fatty particles, and, by its alkaline salts, partly saponify the fatty acids, thus enabling them to be taken up by the lacteals; and, lastly, to convert into peptones the albuminous and gelatinous substances of food. It is an alkaline fluid, very similar to that secreted in the salivary glands, but contains no sulpho-cyanogen.

Spleen.† — The *spleen* is a very vascular sponge-like organ, and belongs to the class of ductless glands. It varies in size according to the amount of blood in it, fluctuating in weight, consistently with health, between five and ten ounces.‡ It is of a reddish-blue color, is more or less elliptical in shape, and in its natural position is placed with its long axis nearly vertical. It is about five inches (*12.5 cm.*) in length, three to four inches (*7.5 to 10 cm.*) in breadth, and from one to one and a half inches (*2.5 to 3.8 cm.*) in thickness; in volume it varies from 9¾ to 15 cubic inches (*or 159.25 c. cm. to 245 c. cm.*). Its *outer surface* is smooth and convex, and corresponds to the ninth, tenth, and eleventh ribs on the left side, being in relation with the under

* The other ductless glands are the thyroid, thymus, and supra-renal capsules.

† "It lies very obliquely, its long axis coinciding almost exactly with the line of the tenth rib. Its highest and lowest points are on a level, respectively, with the ninth thoracic and first lumbar spines; its inner end is distant about one inch and a half (*3.8. cm.*) from the median plane of the body, and its outer end reaches the mid-axillary line." — QUAIN.

The ventral margin may be outlined on a line drawn from the left steno-clavicular articulation to the tip of the eleventh rib. — A. H.

‡ In ague and other forms of fever it sometimes attains a weight of from 18 to 20 pounds (*8.1 to 9 kilograms*); it diminishes in weight after forty years of age, and is enlarged during and after digestion.

aspect of the diaphragm; its *inner surface* is concave, and is adapted to the cardiac end of the stomach; this surface is divided into a larger anterior and a smaller posterior portion by a vertical fissure — the *hilum* — at the bottom of which are large openings, through which the vessels enter and emerge from the spleen. The borders are: an *upper*, thick and rounded; a *lower*, pointed; a *posterior*, rounded; and an *anterior*, also rounded, and often notched.

As already mentioned, the spleen is connected to the stomach by the *gastro-splenic omentum*, and to the under aspect of the diaphragm by the *suspensory ligament*.

The spleen is invested with two coats — a serous or peritoneal, and a fibro elastic. The *outer* or *serous coat* entirely covers the organ, except at the hilum, from which it is reflected to the stomach; it is thin and smooth, and is intimately connected to the subjacent fibrous coat. Its *fibro-elastic coat* (tunica propria), thick and strong, not only covers the spleen, but sends inwards throughout its substance fibrous bands (*trabeculæ*), which interlace in all directions, and thus form an intricate network of what are termed *trabecular spaces* or *areolæ;* this coat consists of a strong, white, and elastic tissue, and is consequently exceedingly elastic to admit of the varying size of the spleen; it moreover contains more or less unstriped muscular fibres, so that it contracts faintly on the application of the galvanic current. Besides this, the trabeculæ form sheaths and supports for the splenic vessels throughout their ramifications.

The areolæ, above described, are filled with what is termed the *spleen pulp*. This pulp is a soft reddish-brown substance, and under the microscope is seen to consist of connective-tissue corpuscles, which with their branched communicating processes, called the *sustentacular cells of the pulp*, make up a fine reticular tissue, the interstices of which are filled with red and white blood-corpuscles. Thus the areolæ are divided into a large number of smaller spaces by these sustentacular cells, and the white blood-cells contained within them are more numerous than in normal blood, especially in the neighborhood of the Malpighian corpuscles. The cells have either one or more nuclei according to their size, and present distinct amœboid movements. In these cells frequently small yellowish granules may be distinguished, which are probably derived from blood-cells, for they present all the characters of hæmatin. Blood-corpuscles in all stages, from an unchanged disk to one of complete disintegra-

tion, may be seen; and it has been shown by Klein that some of them present knob-like projections, as if from budding of small nuclei by a process of gemmation.

The *splenic artery* enters the hilum of the spleen by several branches which ramify in its substance, ensheathed and supported by its fibrous framework.* The artery is remarkable for its large size, as compared with the organ to which it is distributed, and also for its serpentine course. The smaller branches leave the trabeculæ, still invested by a sheath derived from the fibro-elastic coat of the spleen; but, before they terminate in penicillate tufts the sheath becomes changed into a thick investment of lymphoid tissue, which surrounds the smallest arterioles. The lymphoid tissue, which forms the sheath of the arterioles, is here and there dilated into oval enlargements, called the *Malpighian corpuscles*, varying in size from $\frac{1}{70}$th to $\frac{1}{25}$th of an inch (*.3 to 1 mm.*) in diameter. These bodies are sometimes thickenings on the side of the arterioles, but more commonly they completely surround the vessels. They are visible in a fresh spleen, and look like white spots scattered through the dark pulp. There do not appear to be any definite boundaries between them and the reticular tissue; their interior consists of a fine reticulum, denser at the circumference than at the centre, and is filled with lymphoid cells possessing amœboid movements. The smaller arteries, after branching in all directions, enter the spleen pulp, and their lymphoid walls alter in character, presenting numerous branched processes which communicate with the branched cells of the sustentacular tissue. Through this connection they pour their blood directly into the pulp tissue, and thus into relation with the constituents of the pulp tissue, by which means it is subjected to important changes. The *veins* commence in the pulp tissue in the same way as the arteries, and are at first formed by the arrangement into rows of the connective-tissue corpuscles, which subsequently become spindle-shaped and overlap each other, so constituting a variety of endothelial lining to the venous passages. Assuming more the ordinary character of veins, they travel along the trabeculæ like the arteries, but do not accompany them, and freely communicate with each other, and so far are unlike the arteries. The small veins present transverse lines

* The ramifications of the splenic artery may be seen by washing away the pulp and floating the flocculent-looking spleen in water.

or markings, caused by the encircling elastic fibres around the vessels of the sustentacular tissue of the spleen. After entering the trabecular tissue, which forms sheaths for the veins, they gradually join and form four to six large veins, which leave the hilum to constitute the splenic vein.

The *lymphatics* of the spleen are arranged in two sets — a *trabecular* and a *perivascular* : the former originate in the trabeculæ, and are connected with the lymphatics beneath the capsule; the latter arise in the lymphoid tissue around the arteries, and subsequently run one on each side of the arteries, anastamosing frequently by transverse branches. The trabecular and perivascular lymphatics join at the hilum, and run between the layers of the gastro-splenic omentum to the lymphatic glands.

The *nerves* come from the solar plexus and the right pneumogastric nerve.

The function of the spleen appears to be that of a great blood-gland, and thus concerned in the development of white corpuscles; for the blood which is conveyed from the spleen contains a large excess of white corpuscles. The large number of red blood-corpuscles, in various stages of disintegration, also points to another use of the spleen as the gland for the degeneration of red blood-cells into pigment, which is conveyed through the spleen to the liver to be used in the secretion of the bile. It is also presumed that the gland elaborates the albuminous materials of food, and stores them up for a time before they pass into the circulation.

Kidneys. — The kidneys, two in number, are situated in the lumbar region, behind the peritoneum, imbedded in fat. The left, usually situated higher than the right, is generally longer and somewhat heavier. Their color is reddish-brown. Each is about 4.4 inches (*11 cm.*) in length, two inches (*5 cm.*) in breadth, and one inch (*2.5 cm.*) in thickness. Each weighs from four to six ounces (*113.5 to 170 gm.*) in the male, and in the female, four to five and a half ounces (*113.5 to 156 gm.*).

The kidney presents for examination two surfaces, two borders, and an upper and a lower end.

Topography. — The kidney according to Morris is bisected by the horizontal and vertical planes, which form the hypochondriac, epigastric, umbilical and lumbar regions; its upper level corresponding to the twelfth thoracic vertebra; its lower level that of the second lumbar vertebra; the right lying one-half inch (*13 mm.*) lower than the left. The *anterior, ventral,* or *visceral surface* of the *right kidney* is in contact with the liver, a portion of the descending duodenum, ascending colon, and the

right colic vessels. The *anterior*, or *visceral surface* of the *left kidney* is in contact with the stomach, the pancreas, splenic vessels, the descending colon, and the left colic vessels.

The *posterior surfaces* of both kidneys are in front of a portion of the eleventh and twelfth ribs, first and second lumbar vertebræ, covered by the diaphragm and crura of the same; the psoas, transversalis and quadratus lumborum muscles, covered by their respective fascial and the twelfth thoracic, the ilio-hypogastric, the ilio-inguinal and the first and second lumbar nerves. The left kidney overlaps a portion of the spleen. From this relation it is possible for an abscess in the peri-renal fat to enter the pleural cavity or a stab wound to perforate the thoracic and abdominal cavities before entering the kidney. The *upper extremity* is topped by the supra-renal capsule which overlaps the visceral surface and mesial border. The kidneys are inclined downwards and outwards (*latero-caudad*).

The *anterior surface* is convex, and is covered with peritoneum, and looks somewhat outwards; the *posterior surface* is rather flattened, and rests on the anterior layer of the lumbar aponeurosis and psoas magnus; the *outer border* is convex and rounded; the *inner border* presents, about its middle, a deep notch about an inch (*2.5 cm.*) in length, the *hilum*, leading to a hollow in the kidney, the *sinus*, for the entrance and exit of the renal vessels and ureter, the nerves and lymphatics; these have the following relations to one another: in front lies the renal vein; behind is the ureter; between them is the renal artery; the *upper end* is large and thick, and looks upwards and inwards or *cephalo-mesial*, and superimposed rests its corresponding supra-renal capsule; the *lower end*, smaller and flatter than the upper end, looks downwards and outwards, *caudo-laterad*.

The kidney is surrounded by a thin *fibrous capsule* of thick connective tissue, to which it is loosely connected by areolar tissue and minute vessels, except at the hilum; here it is reflected inwards and becomes continuous with the walls of the renal vessels and ureter. The capsule can be readily stripped off when healthy, leaving the surface perfectly smooth.*

A longitudinal section should be made through the kidney,

* Under the capsule there have been traced unstriped muscular fibres forming an incomplete layer.

from the outer to the inner border, to demonstrate the interior. This section displays two distinct parts — an *outer* or *cortical portion*, and an *inner* or *medullary portion.*

The *cortical structure* is deeper in color than the medullary portion, and is soft and easily lacerated. This portion forms

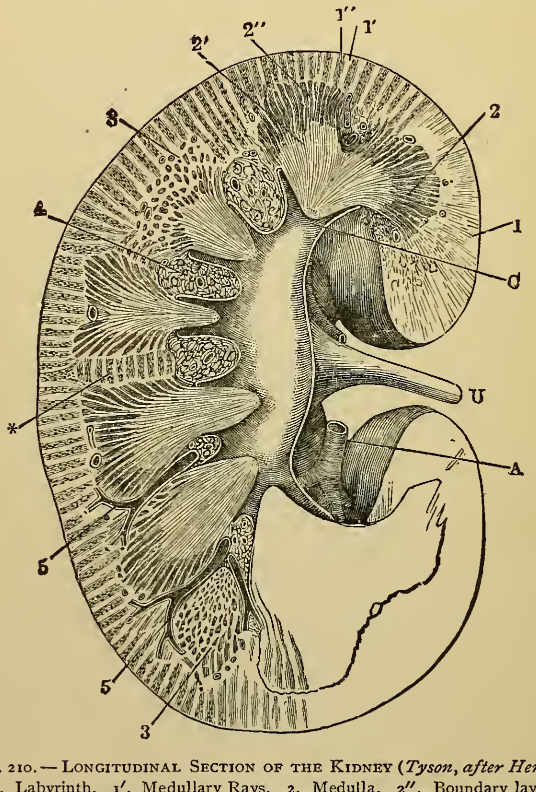


Fig. 210. — Longitudinal Section of the Kidney (*Tyson, after Henle*).

1. Cortex. 1''. Labyrinth. 1'. Medullary Rays. 2. Medulla. 2''. Boundary layer of medulla. 2'. Papillary portion of medulla. 3. Transverse section of tubules in boundary layer. 4. Fat of renal sinus. *. Transversely coursing medullary rays. 5. Artery. C. Renal calyx. U. Ureter. A. Branch of renal artery.

$\frac{1}{5}$ to $\frac{1}{4}$ of an inch (*5 to 6 mm.*) of the outer part of the kidney, arching over the bases of the pyramids. It moreover sends down prolongations between the pyramids as far as the sinus, forming the *septula renum* or the *columns of Bertini.* The cortical substance consists of convoluted and straight tubes, *tubuli uriniferi,* of little reddish granules called *Malpighian bodies,* and of blood-vessels, nerves and lymphatics (Fig. 210).

The *medullary structure* is composed of numerous conical masses, the *pyramids of Malpighi*, having their bases directed to the surface, their sides in relation with the columns of Bertini, and their apices, termed *papillæ*, or *mamillæ*, projecting into one of the calices of the ureter. The pyramids, of which there are from eight to sixteen, are surrounded by the cortical substance; they are composed of minute straight tubules (which proceed from the cortical portion to end in the papillæ), of looped tubes described by Henle, and of arteries and veins.*

At the hilum is the dilated commencement of the ureter, called the *pelvis of the kidney*. It is funnel-shaped, and its broad part divides into three principal channels, *infundibula*, an upper or cephal, middle or mesial, and lower or caudal, which again branch, and form from eight to twelve cup-like excavations, called *calices*. Into each of these calices one, sometimes two or more papillæ project. Between the calices the branches of the renal artery ascend to ramify in the kidney, lying embedded in fat. The pelvis and the calices are composed of three layers — an *external* or *cortical fibrous layer* continuous with the reflected part of the capsule into the sinus; a *mesial* or *muscular*, consisting of longitudinal and circular fibres, the former extending nearly as far as the calices, the latter encircling the calyx around the papillæ; and an *internal intima*, or *mucous coat* reflected over the papillæ.

Structure of the Kidney. — With a lens each papilla may be seen to be studded with 24 to 80 apertures, which are the terminations of the *tubuli uriniferi*. These apertures open into the bottom of about twenty shallow depressions on a papilla, called *foveolæ*. The orifices are from $\frac{1}{160}$th to $\frac{1}{125}$th of an inch (*200 to 300* μ†) in diameter. These tubes as they pass out into the pyramidal structure run straight, bifurcate repeatedly at very acute angles, their subdivisions running parallel, and reach the bases and sides of the pyramids, from which they pass into the cortical substance, greatly increased in number. These, termed the *straight* or *collecting tubes* (Fig. 212, *o*), pass into the

* Each pyramid represents what was, in the early stage of the kidney's growth, a distinct and independent lobe. In the human subject the lobes gradually coalesce, and no trace of their primordial state remains, except the pyramidal arrangement of the tubes. But in the kidneys of the lower mammalia, of birds and reptiles, the lobes are permanently separate.

† μ, micromillimeter.

cortical substance still as straight tubes, the central ones passing nearly to the surface, the outer ones being very short, and only run a short distance into the cortex, so that they are ar-

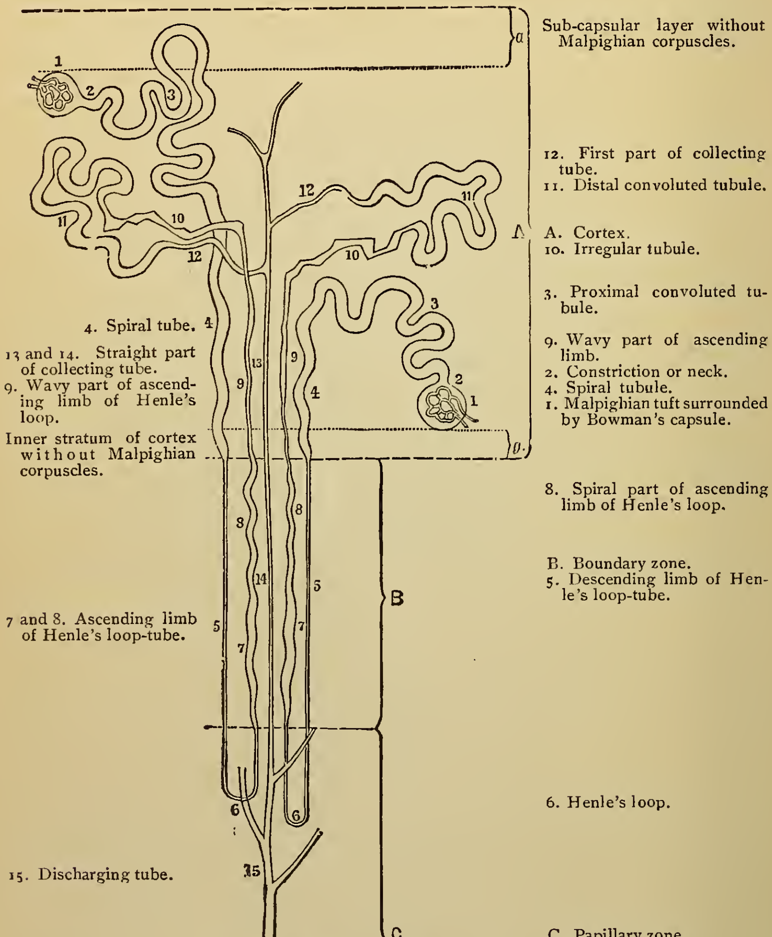


FIG. 211.—DIAGRAM OF THE COURSE OF TWO URINIFEROUS TUBULES.

ranged as a series of cones, with their apices to the surface of the organ. These bundles are called the *pyramids of Ferrein*, or the *medullary rays*, and receive on each side the curved extremities of the convoluted tubes. We find the cortical sub-

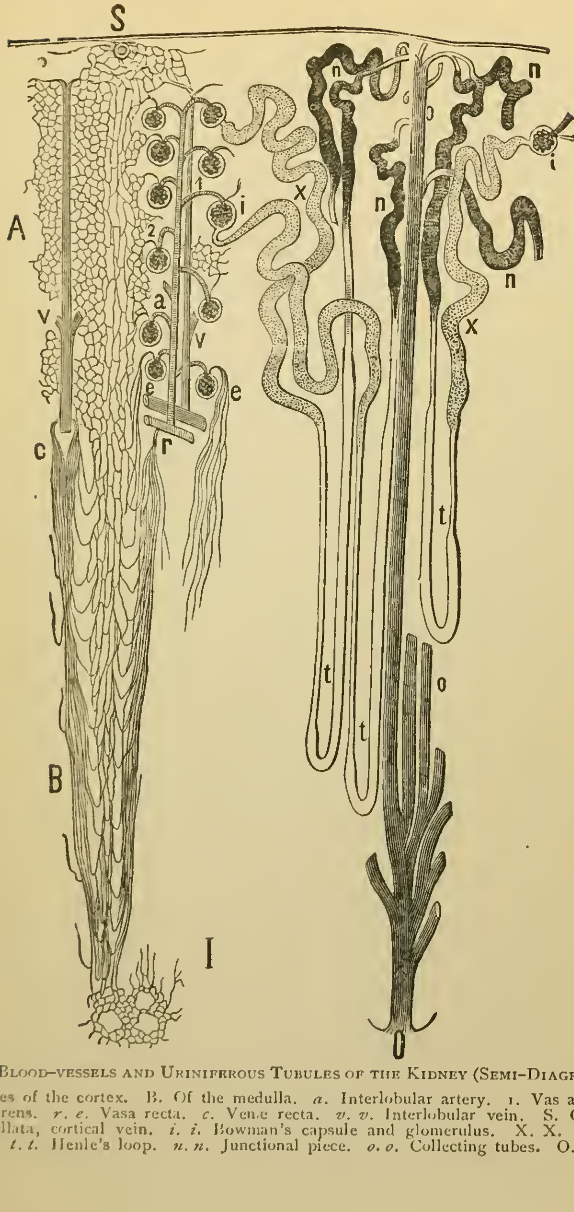


FIG. 212. — BLOOD-VESSELS AND URINIFEROUS TUBULES OF THE KIDNEY (SEMI-DIAGRAMMATIC).

A. Capillaries of the cortex. B. Of the medulla. *a*. Interlobular artery. 1. Vas afferens. 2. Vas efferens. *r. e.* Vasa recta. *c.* Venæ rectæ. *v. v.* Interlobular vein. S. Origin of a vena stellata, cortical vein. *i. i.* Bowman's capsule and glomerulus. X. X. Convoluted tubules. *t. t.* Henle's loop. *n. n.* Junctional piece. *o. o.* Collecting tubes. O. Excretory tube.

stance is arranged between and around these medullary rays, which, from the intricate arrangement of its tubes, receives the name of the *labyrinth of the cortex.*

Each uriniferous tubule commences in a dilated extremity, termed the *Malpighian capsule* (300μ) (Fig. 211, 1), in which is enclosed an arterial, vascular tuft, the *Malpighian tuft*, of about $\frac{1}{130}$th of an inch in diameter, and is visible to the naked eye as a minute red point. At the point of union of the tubule with the capsule it presents a narrow portion, called the *neck* (2), beyond which the tubule becomes convoluted for a considerable distance, forming the *first* or *proximal convoluted tube* (3). As it descends toward the medullary ray, the tubule becomes nearly straight, but having a slight spiral tendency: this portion of the tube is termed the *spiral tubule* (4) (Schachowa). The tubule now enters the medullary portion, narrowing very suddenly in its calibre, and descends towards the apex of the pyramid, constituting the *descending limb of Henle's loop* (5). The tubule here bends upon itself, forming a loop, the *loop of Henle* (6), and ascends to re-enter the cortical substance as the *ascending limb of Henle's loop* (7), which is larger than the descending limb. On passing out of the medullary ray of the cortical portion the tubule becomes irregularly dilated, and takes the name of the *irregular tubule* (8, 9); this is continued on into another convoluted portion, called the *second, irregular* or *distal convoluted tubule* (10, 11), which, before entering the straight tube, becomes much narrowed and curved, called the *primitive collecting* or *junctional tubule*. We have thus traced the straight tubes from their termination at the papillæ to their commencement at the pyramids of Ferrein, and have also traced the convoluted tubules from their origin in the Malpighian capsules to their junction with the commencement of the straight tubes.

The tubuli uriniferi consist of a basement membrane lined with epithelium, which varies in the different parts of the tubuli. The *capsule* is lined with flattened cells, having oval nuclei; the *neck* (Fig. 213, II.) has cubical epithelium; the *first convoluted tubule* is lined with polyhedral epithelium, presenting numerous rod-like processes, resting at one end on the basement membrane, while the other extends towards the lumen of the tubule, and thus presents the appearance of striation; the *spiral tube of Schachowa* has similar epithelium; the *descending limb* is lined with flattened epithelium, like that in the capsule; the *ascending limb* presents epithelium similar to that found in the first convoluted and spiral portion of the tubule, although smaller and with shorter rod-like processes; the *irregular tubule* is furnished with the rod-like cells of unequal length, which, however, render the lumen more uniform; the *second convoluted tubule* has epithelium somewhat like that of the first convoluted tubule, but having long cells with large nuclei, and possessing high refractive properties; the *curved* or *junctional tubule*

has a large lumen, and is lined by angular or fusiform cells with short processes; the *collecting* or *straight tubes* are lined with cubical epithelium, which in the larger tubes becomes distinctly columnar.

The *renal artery* enters the hilum between the pelvis and the renal vein. It shortly divides into four or five branches, which pass outwards between the papillæ, and then enter the cortical portion between the pyramids. From these there pass to each Malpighian pyramid two branches, which ascend along its sides as far as its base, distributing in their course small vessels which pass to the Malpighian capsules. At the base of the pyramid they form arches, and make a bend from which two sets of branches are given off, the interlobular arteries and the arteriolæ rectæ (Fig. 212, *r. e.*).

The *interlobular arteries* (*a*) pass off at right angles between the medullary rays, and then run amongst the convoluted tubes, some to enter the Malpighian capsules, and others to reach the surface and supply the capsule, ending in the stellate veins beneath the capsule. The arteriole which passes to the Malpighian capsule is termed the *afferent vessel* (1), and, entering the dilated extremity of the

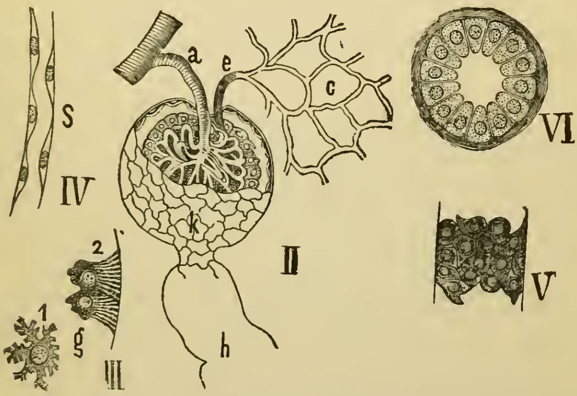


FIG. 213.—II. BOWMAN'S CAPSULE AND GLOMERULUS.

a. Vas afferens. *e.* Vas efferens. *c.* Capillary network of the cortex. *k.* Endothelium of the capsule. *h.* Origin of a convoluted tubule. III. "Rodded" cells from a convoluted tubule —2, seen from the side, with *g*, inner granular zone. 1. From the surface. IV. Cells lining Henle's looped tubule. V. Cells of a collecting tube. VI. Section of an excretory tube.

uriniferous tube, breaks up into a number of convoluted capillary vessels, constituting the *glomerulus* of Malpighi. The blood is returned from the glomerulus by a small *efferent vein*, which emerges from the capsule close to the entrance of the artery. This vein (2), after a short course, breaks up, like an artery, into a dense network of capillaries, which ramify over the convoluted tubules (*v. v.*). Some of the veins from the lower glomeruli break up into straight vessels, and then pass from the medullary rays into the pyramid.

The *arteriolæ rectæ* are destined for the supply of the Malpighian pyramids, entering them at their bases, and then passing downwards to their apices, where they join the venous plexuses.

The *Malpighian bodies* are small red granular masses about $\frac{1}{120}$th of an inch in diameter, and are only found in the cortical substance. Each is composed of the dilated commencement of a uriniferous tube forming the *Malpighian capsule*, containing within it a coil of small blood-vessels called the *Malpighian tuft* or *glomerulus*. The capsule is composed of a homogeneous membrane, and is pierced by a small artery, *afferent vessel*, which enters it opposite the commence-

ment of the urinary tubule. In the capsule the artery breaks up into a coil of minute blood-vessels, *glomerulus*, and returns its blood by a vein, *efferent vessel*, which emerges from the capsule close to where the artery entered. The capillary plexus within the capsule is surrounded by the epithelium lining the interior of the capsule.*

The *renal veins* return the blood from three sources: from the veins situated beneath the capsule (Fig. 212, S.), and those corresponding to the interlobular arteries which pass between the medullary rays (*v. v.*), and at the bases of the Malpighian pyramids join the venæ rectæ (*c.*) ; the venæ rectæ return the blood from the arteriolæ rectæ, and begin in plexuses at the apices of the pyramids; they then pass outwards between the tubuli recti, and join the interlobular veins to form the proper renal veins; these pass down along the sides of the Malpighian pyramids, accompanied by their corresponding arteries, and in their course to the sinus receive the efferent veins from the adjacent cortical substance. At the sinus they communicate freely with each other and join to form the renal vein.

The *nerves*, about fifteen in number, forming the renal plexus, are derived from the lesser and smallest splanchnic nerves, the solar plexus, and the semilunar ganglion.

The *lymphatics*, consisting of a deep and a superficial set, pass to the lumbar glands.

Supra-renal Capsules. — These bodies, situated at the top of or cephalad to the kidneys, are below or caudo-ventrad to the diaphragm, and anterior or ventrad to the tenth rib or eleventh intercostal space, and separated from each other about two and a half inches: they belong to the class of ductless glands. They are of yellow-ochre color; the right is triangular, and resembles a cocked hat; the left is more almond-shaped and rather the larger of the two. They measure about an inch and a half (*right, 3.8 cm.; left, 5 cm.*) in their long diameter, about three-quarters (*right, 18 mm.; left, 2.5 cm.*) in breadth, and $\frac{1}{6}$ to $\frac{1}{4}$ of an inch (*4 to 6 mm.*) in thickness; they weigh from one to two drachms † (*4 to 8 gm.*). The gland is surrounded by connective tissue and fat, and is invested by a thin fibrous covering, which sends down partitions into the interior through furrows on their surface.

A perpendicular section shows that it consists of a firm exterior or cortical part, and of an interior or medullary substance, soft and pulpy.

* Histologists differ with respect to the disposition of the epithelium over the glomerulus; some assert that it has no epithelial covering, but that it hangs loose with the capsule; some, that the tuft is completely invested with epithelium, except where the afferent and efferent vessels pass in; others, again, that only that portion of the glomerulus which looks towards the neck of the tubule is covered with epithelium.

† Many authors give a much larger weight, varying from 7 gm. (two drachms) to 19 gm. (five drachms); the gland is larger in young adolescence, but atrophies in old age. — A. H.

The *cortical portion* is of a yellow color and forms the principal part of the organ. It consists of parallel columns arranged perpendicularly to the surface, due to the capsule sending processes into the interior of the gland, which communicate at frequent intervals by transverse bands. There are thus formed numerous spaces which communicate with each other; the spaces at the surface are smaller, while those towards the centre are longer; the section through the cortex gives the appearance of a fine network, the external portion taking the name of the *zona glomerulosa*, the internal portion that of the *zona reticularis*, the intermediate portion that of the *zona fasciculata*. The reticular tissue is made up of fibrous tissue with longitudinal bundles of unstriped muscular tissue.

The *medullary portion* varies in color according to the amount of blood contained in it, being sometimes a dark-brown color, sometimes nearly white. Not infrequently the medullary part is converted into a cavity, but this is probably a post-mortem change. It consists of a plexus of minute veins, supported by the delicate areola tissue containing muscular fibres, and presents a reticular aspect. Among these are numerous granular and branched cells.*

The *arteries* to the gland are conveyed along the trabecular tissue, and, after supplying the gland-tissue, converge to the centre, where the blood is returned into the venous plexuses in the medullary portion. They are derived from the abdominal aorta, the phrenic and the renal arteries. The *vein* begins in the centre as a single vessel, and joins, on the right side, the inferior vena cava, and on the left side the left renal vein.

The *lymphatics* terminate in the lumbar glands.

The *nerves* are derived from the solar and renal plexuses, and in them are found numerous ganglia. They are distributed chiefly to the medullary portion.† Of late years the minute structure and functions of the supra-renal capsules have been much investigated, in consequence of the discovery made by Dr. Addison, of the close relation which exists between certain diseases in these bodies and a brown discoloration of the skin. Their precise function is still unknown.

Stomach and Intestines.—The alimentary canal is composed of four coats: a serous, a muscular, a submucous, and a mucous. First, is the *serous* or *peritoneal* coat, described at p. 457. Secondly, under the serous is a *muscular* coat, upon which the chief strength of the canal depends. It consists of two distinct strata of plain muscular fibres; the outer or cortical stratum is longitudinal, the inner or mesial circular. The arrangement not only makes the bowel stronger, but regulates its peristaltic action, for the longitudinal fibres, by their contraction, tend to shorten and straighten the tube, while the circular fibres contract upon and propel its contents to greater advantage. Connecting this coat and the mucous, is a layer of areolar tissue called the *submucous coat*, in which the arteries break up before entering the mucous membrane. The *mucous* is the most complicated of all the coats, for it

* The medullary cells are stained a deep brown color on the addition of bichromate of potash, the cortical cells being scarcely affected by it.

† Luschka states that the branched granular cells of the medullary portion are connected with the nerve-fibres.

presents different characters in different parts, according to the functions which it has to perform.

Stomach. — The stomach should be moderately distended to see its size, which varies in different subjects according to the habits of the individual. When distended, an average stomach would be about ten or twelve inches (*25 to 30 cm.*) in length, and four (*10 cm.*) in depth and width ; its weight is stated to be about four and a half ounces (*about 130 gm.*) (*capacity 6½ lbs. or 3.4 kilgm.*). It is conical in shape; the left part forms a large bulge called the *cardiac* or *splenic end;* and on the right side where the food passes out it becomes small and contracted, and is called the *pyloric end.* The stomach presents for examination two surfaces, two borders, two ends, and two orifices.

Topography of the Stomach. — It is placed mesially in the abdominal cavity : in *front* or *ventrad* to it are the abdominal wall, diaphragm, and liver ; *above* or *cephalad* to it are the gastro-hepatic omentum, liver, and diaphragm ; *below* or *caudad* to it are the great omentum, transverse colon, and gastro-splenic omentum ; and *behind* or *dorsad* to it are the transverse meso-colon (always in children), pancreas, solar plexus, great vessels, spleen, left kidney, supra-renal capsule and crura. The cardiac end is on a level with the sixth chondro-sternal joint, being necessarily above and behind or cephalo-dorsad to the heart apex. The cardiac orifice is dorsad to the seventh left costal cartilage about one inch (*2.5 cm.*) from the sternum, and ventrad to the tenth and eleventh thoracic vertebræ. The pyloric end is nearer the ventral abdominal wall, but on a lower or caudal plane than the cardiac end, being posterior or dorsad to a line drawn at the junction of the seventh ribs with their cartilages and two or three inches (*5 or 7.5 cm.*) from the sterno-xiphoid joint, and also ventrad to the twelfth thoracic spine. — A. H.

The *anterior surface* is convex, and looks upwards and forwards, cephalo-ventrad ; the *posterior surface* looks downwards and backwards, caudo-dorsad.

The *upper border* or the *lesser curvature* is concave and short, and extends from the œsophagus to the pylorus ; it is connected to the liver by the gastro-hepatic omentum. The *lower border* or the *greater curvature* is convex, and affords attachment to the great omentum.

The *left end* is the larger, and is called the *cardiac* or *splenic end;* it bulges out to the extent of two or three inches (*5 to 7.5 cm.*) to the left of the entrance of the œsophagus, and is

called the *great cul-de-sac* or *fundus*. The *right end* is narrow, and makes a double bend; near the first it bulges into a pouch, called the *antrum pylori*, or the *small cul-de-sac*.

The *œsophageal* or *cardiac orifice*, situated at the highest part of the stomach, is on the left, and receives the œsophagus; the *pyloric orifice* is continued on into the duodenum, and is narrow, being guarded by a musculo-mucous ring, the *pylorus*.*

The stomach is connected at its borders by peritoneal folds extending to neighboring structures; thus, its lesser curve is connected with the transverse fissure of the liver by the gastrohepatic or lesser omentum; its cardiac end is connected with the hilum of the spleen by the gastro-splenic omentum; to the left of the œsophagus it is connected with the diaphragm by the gastro-phrenic ligament; to its greater curve is attached the great omentum, which is continuous on the left side with the gastro-splenic omentum.

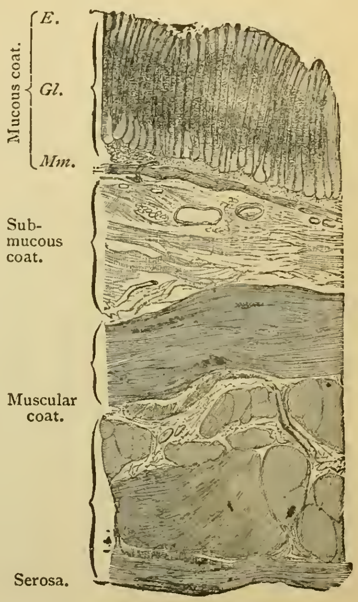


FIG. 214.—VERTICAL SECTION OF THE WALL OF THE HUMAN STOMACH × 15. *E*. Epithelium. *Gl.* Glands. *Mm.* Muscularis mucosæ.

The *pylorus* is the narrow circular ring, composed of circular muscular fibres and mucous membrane, through which the food passes into the duodenum. The serous and longitudinal muscular fibres take no part in its formation, being continued over it on to the duodenum.

The stomach consists of four coats: serous, muscular, submucous, and mucous.

The *serous* or *peritoneal coat* covers the surface of the stomach, except at the borders, where the peritoneum is continued

* The position of the stomach within the abdomen, and its relations with surrounding structures, are matters of much dispute. Dr. Lesshaft has come to the conclusion that the stomach is nearly vertical, so that its fundus touches the diaphragm (See *Lancet*, March 11, 1882, p. 406). His, and most anatomists, are of opinion that the long axis is placed obliquely from left to right within the abdomen.

as omenta to other organs; it is along these borders that the vessels run.

The *muscular coat* can be seen when the serous coat is removed. The fibres are of the unstriped variety, and arranged

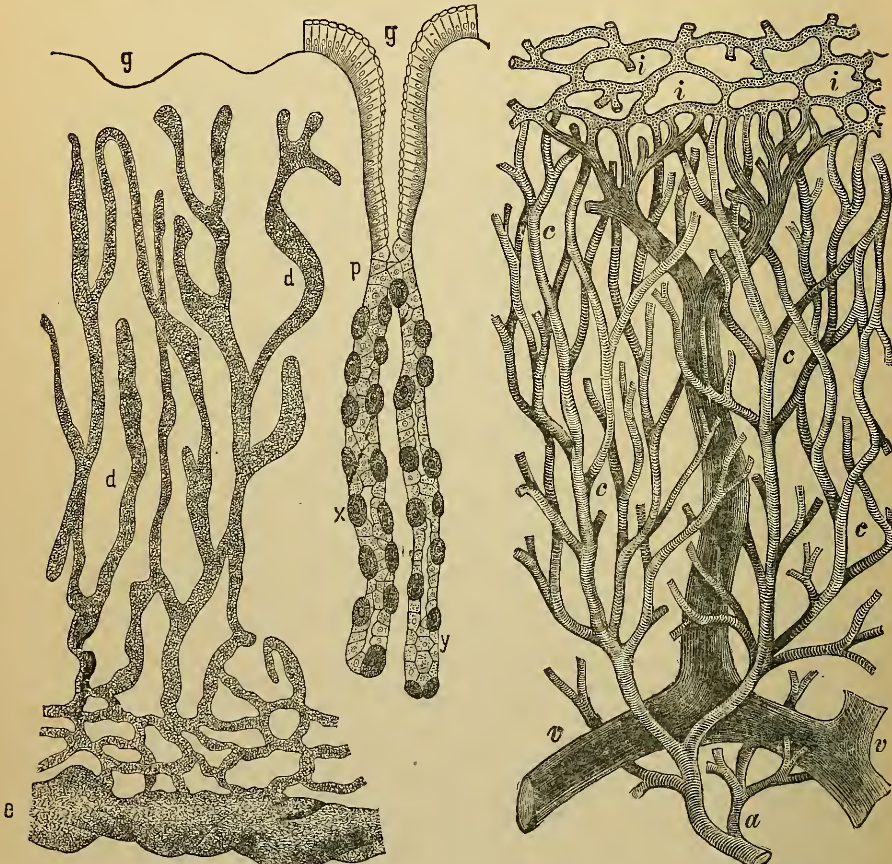


FIG. 215.—VERTICAL SECTION OF THE GASTRIC MUCOUS MEMBRANE. *g*, *g*. Pits on the surface. *p*. Neck of a fundus-gland opening into a duct. *g*, *x*. Parietal, and *y*, chief cells. *a*, *v*, *c*. Artery, vein, capillaries. *d*, *d*. Lymphatics, emptying into a large trunk, *e*.

in three layers: an external or longitudinal, a middle or circular, and an internal or oblique.

The *longitudinal fibres* are continuous with the longitudinal fibres of the œsophagus, and spread out over the stomach, being most numerous along the curvatures of the stomach; they are

at the pyloric end continuous with the longitudinal fibres of the duodenum. The *circular fibres* are well marked about the middle of the stomach, but are most abundant at the pylorus, where they form a powerful sphincter.

The *oblique fibres* are scattered over the sides of the stomach, and are most distinct at the entrance of the œsophagus, crossing obliquely from left to right and from right to left. They are continuous with the well-marked circular fibres of the œsophagus.

The *submucous coat* serves to connect the muscular with the mucous coats. It consists of areolar tissue, and permits the muscular and mucous coats to move freely on each other, and allows the blood-vessels to ramify minutely before they enter the mucous membrane.

When the stomach is laid open from the œsophageal to the pyloric orifice, the *mucous membrane* is seen to be thick, of pale-pink or straw color, and is gathered into longitudinal folds — *rugæ* — which disappear when the stomach is distended.

If a portion of the mucous membrane be examined under the microscope, its surface will be seen to be mapped out into small hexagonal pits or *alveoli*, surrounded by ridges, giving it a honeycombed appearance. At the bottom of them are a number of minute apertures, the orifices of the *gastric follicles*. In a perpendicular section the follicles are arranged in parallel lines at right angles to the surface, and terminate in blind sacculated ends set in the submucous tissue. The entire thickness of the mucous membrane is made up of these tubular glands. The follicles consist of two kinds, *mucous* and *peptic glands*. Tubular in shape, they have a basement membrane lined with epithelium, and average about $\frac{1}{40}$th of an inch long, and $\frac{1}{400}$th of an inch in diameter. The *mucous glands* are found over the whole surface, but are most numerous at the pyloric end of the stomach. They are composed of tubes, each consisting of two or three short tubules, opening into a common duct, which itself opens into the bottom of an alveolus. They are lined with columnar epithelium, continuous with that lining the mucous membrane. The *peptic glands* are also found over the entire surface of the mucous membrane, and consist of tubules with branched cæcal extremities opening into a common duct, which is, however, shorter than that of a mucous gland. They are lined with columnar epithelial cells, called the *central cells*, and are supposed to be concerned in the secretion of the gastric juice; these cells become, at the neck of the gland, much shorter and more granular. The lumen of the gland is very small, but is somewhat larger at the free and the cæcal ends than in the middle. Toward the lower part or fundus of the gland there are found spheroidal and granular cells between the epithelium and the basement membrane, called *parietal cells*.

In the stomachs of young children there is a large amount of lymphoid tissue found between the gastric glands. It is aggregated into small masses in the mucous membrane, and resembles, in many respects, the solitary glands of the intestine, although not so well defined.

The mucous membrane of the stomach is lined by columnar epithelium, which also extends into the glands. A thin layer of unstriped muscular tissue (muscularis mucosæ) is found between the mucous membrane and its submucous tissue, varying in amount and in the number of its layers.

The glands of the stomach are richly supplied with blood, which is derived from the gastric, the vasa brevia, the right and left gastro-epiploica, and the pyloric arteries. The arteries form a stratum of minute inosculations in the submucous tissue, in which the closed ends of the tubes are set; from this stratum the capillary plexuses run up between the tubes to the surface of the stomach, where they

again form a larger capillary plexus, and form the hexagonal spaces before alluded to. The *veins*, corresponding to the pyloric and gastric arteries, end in the vena portæ; those corresponding with the vasa brevia and the epiploic arteries open into the splenic vein.

The *lymphatics* enter the glands along the lesser and greater curvatures of the stomach, and may be divided into a superficial and a deep set.

The *nerves* are derived from the pneumogastric nerves and from the solar plexus.

Small Intestine.—The small intestine, consisting of the duodenum, jejunum, and ileum, forms a tube averaging twenty feet in length, which gradually lessens in calibre until it opens into the cæcum. The duodenum is about twelve fingers' breadth (*10 inches or 25 cm., and two inches or 5 cm. in diameter*) in length, whence its name; the jejunum comprises two-fifths, the ileum three-fifths, of the remaining part of the small intestine. As regards their external or cortical characters, the duodenum and jejunum are more vascular than the ileum, and feel thicker in consequence of the peculiar arrangement of their mucous membrane; but there are no defined limits between the different portions of the intestinal canal.

Its coats are four in number: serous, muscular, submucous, and mucous. The *serous coat* consists of peritoneum, and forms a complete investment, except in the case of the descending, transverse, and second ascending portions of the duodenum, which are only partly covered.

The *muscular coat* consists of an outer longitudinal layer and an inner circular thicker layer, which, however, becomes thinner towards the end of the ileum.

The *submucous coat* connects the muscular and mucous coats; immediately beneath the mucous membrane there is a very thin layer of non-striped muscular fibres, termed *muscularis mucosæ.*

The *mucous coat* can only be seen when the intestine is cut open from the upper end, and is composed of the following strata: the muscularis mucosæ, a layer of retiform tissue with lymph corpuscles, with blood-vessels and nerves; and, lastly, a layer of columnar epithelium.

When the intestine is laid open we see that the mucous membrane is arranged in close transverse folds, called *valvulæ conniventes* or *valves of Kerkring*. These differ from other folds in the alimentary canal—*e.g.*, in the œsophagus and stomach—in that they are not obliterated when the tube is distended. Each fold extends about one-half or two-thirds round the intestine, but they are not all of equal size, and are about one-third of an inch (*8 mm.*) in depth. They commence immediately below the opening of the biliary and pancreatic ducts, and are most developed in the duodenum and the upper part of the jejunum. Below this part of the tube they gradually decrease in size, and become wider apart, till they finally dis-

appear near the middle of the ileum. The use of the valvulæ conniventes is to increase the extent of surface for the absorption of chyle, to prevent the food passing too rapidly through the intestine, and for secretion.

If a portion of small intestine be washed and placed in water, the surface of the mucous membrane appears like the soft fur or pile upon velvet. This appearance is produced by small processes called *villi.* These are extremely vascular projections of the mucous membrane, about $\frac{1}{48}$ of an inch (*.5 mm.*) in length, and are so numerous that $\frac{1}{12}$ of an inch (*2 mm.*) square contains from forty to ninety of them.* Their size, however, and their number, bear a direct ratio to those of the valvulæ conniventes. Under the microscope a villus is seen to consist of an outstanding process of the mucous membrane, covered by a layer of columnar epithelium, which rests upon a basement membrane. Each villus is furnished with an artery which forms a network of inosculations in it, and then returns its blood by a single vein. Down its middle runs a *lacteal* or absorbing vessel, which commences in a closed end near the summit of the villus, where it is surrounded by a layer of pale non-striped muscular fibres proceeding from the *muscularis mucosæ.* This is surrounded by a plexus of capillaries, external to which is the basement membrane supporting columnar epithelium. Forming the matrix of the villus is a fine network enclosing large flattened cells with oval nuclei and lymph cells.

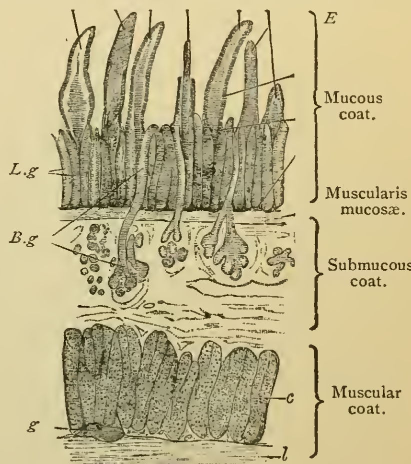


FIG. 216.—VERTICAL SECTION OF THE DUODENUM.
E. Epithelium. *c* and *l.* Circular and longitudinal muscular fibres. *L. g.* Lieberkühn's glands. *B. g.* Brunner's glands. *g.* Ganglion cells. *v.* Villi.

Intestinal Glands.—There are four kinds of *glands* † in the small intestine, called the glands of Lieberkühn, Brunner, Peyer, and the solitary glands. The first and last are distributed over the whole tract of the intestinal mucous membrane; the other two over particular parts.

The *simple follicles* or *crypts of Lieberkühn*, the most numerous of all, are minute tubes with blind ends, very thickly distributed over the small and the large intestines. Under the microscope their orifices are seen between the villi like so many minute dots. Their average length is *.36 mm.*; their walls consist of a delicate basement or endothelial membrane, and are lined with columnar epithelium.

The *duodenal* or *glands of Brunner* are found only in the duodenum and a small part of the beginning of the jejunum. They are just visible to the naked

* Krause estimates the total number of villi at four millions.

† A satisfactory examination of the intestinal glands can be made only in specimens quite recent, taken from young persons who have died suddenly, or from a rapidly fatal disease.

eye, and may be seen by removing the muscular coat. Their structure exactly resembles the round compound glands of the mucous membrane of the mouth.

The *glands of Peyer* (*glandulæ agminatæ*) abound most in the ileum, and are seen most distinctly in children. They are arranged in groups, from twenty to forty in number, on that part of the intestine most distant from the attachment of the mesentery. These groups are from half an inch to three inches (*13 mm. to 7.5 cm.*) long, and one inch (*2.5 cm.*) in width, of an oval form, and increase in size and number towards the lower part of the ileum. If a group be examined by dissecting away the muscular coat, you find that it is composed of a number of small oval vesicles, like Florence flasks, embedded in the submucous tissue. They are composed of masses of lymphoid tissue, of about $\frac{1}{16}$ of an inch (*1.7 mm.*) in diameter, and contain an opaque grayish fluid. No excretory ducts have been

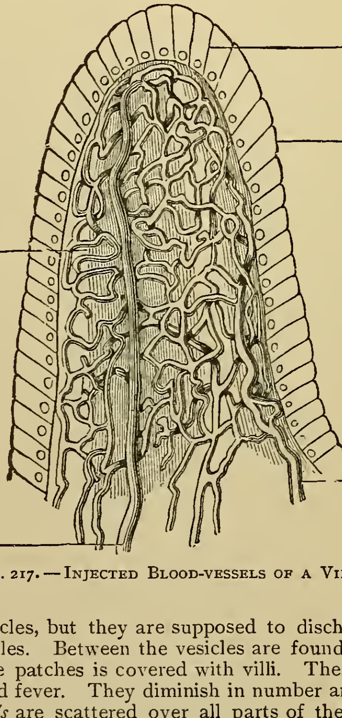


FIG. 217.—INJECTED BLOOD-VESSELS OF A VILLUS.

traced from these vesicles, but they are supposed to discharge their contents by rupture of their capsules. Between the vesicles are found Lieberkühn's follicles, and the surface of the patches is covered with villi. These glands are liable to be ulcerated in typhoid fever. They diminish in number and size with old age.

The *solitary glands* are scattered over all parts of the small and large intestines. They consist of the same lymphoid structure as the glands of Peyer, and only differ from them in being solitary instead of being aggregated into groups.

The *lymphatics* consist of two sets—those of the muscular, and those of the mucous coats; the latter receive those from the villi, at the base of which they form a minute plexus, and, after piercing the muscular coat, join with the former, which are chiefly found between the longitudinal and the circular layers of muscular fibres.

The *nerves* are derived from the superior mesenteric plexus, and accompany the superior mesenteric artery and its branches between the layers of the mesentery; after reaching the intestinal walls the nerve-filaments separate from the arteries.

They then pierce the external longitudinal muscular fibres, and form a very minute gangliated plexus — *Auerbach's plexus*, or *plexus mesentericus* — which distributes filaments to the muscular layer of the entire intestinal canal. From this plexus numerous branches perforate the internal circular muscular layer, and unite to form a largely gangliated plexus — *Meissner's plexus* — in the submucous tissue. The *intermuscular plexus* probably supplies the muscular coat and regulates the peristaltic action of the bowel; the *submucous plexus* determines the calibre of the blood-vessels.

Large Intestine. — The principal external characters of the large intestine are that it is pouched or sacculated, and that it has attached to it little pendulous portions of fat covered by peritoneum, called *appendices epiploicæ.* The pouches (sacculi)

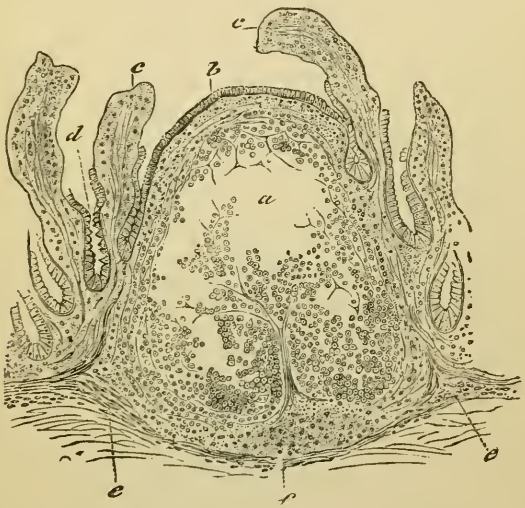


FIG. 218 — SECTION OF A SOLITARY FOLLICLE OF THE SMALL INTESTINE.
a Lymph-follicle covered with epithelium (*b*); but the villi, *c*, are denuded of epithelium. *d.* Lieberkühn's follicle. *e.* Muscularis mucosæ. *f.* Submucous tissue.

are produced by a shortening of the longitudinal muscular fibres, and by their being collected into three bands, about half an inch (*13 mm.*) wide, nearly equidistant from each other. One of these bands corresponds with the attached part of the circumference of the bowel; another with the front part; a third with its concavity. If at any given part the three bands be divided, the pouches immediately disappear.

In a colon moderately distended and dried, we observe that the mucous membrane forms numerous ridges or incomplete septa (Fig. 219); they correspond to the grooves on the external

surface of the bowel, and disappear, like the sacculi, when the longitudinal bands are divided.

The *rectum* differs from the rest of the large intestine in that its longitudinal muscular fibres are not collected into bands, but distributed equally over its whole circumference. Moreover, both the longitudinal and circular fibres are of considerable strength, like those of the œsophagus, as one might expect from the particular functions which these parts of the alimentary canal have to perform.. For an inch and a half (*3.8 cm.*) above the anus, the circular fibres are remarkably developed, and constitute the *internal sphincter ani.*

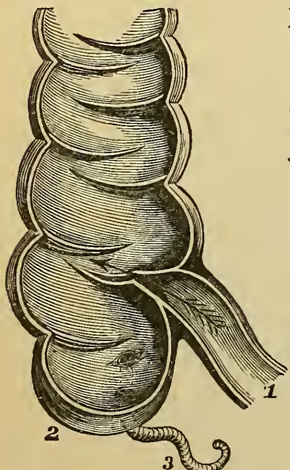


FIG. 219.—SECTION THROUGH THE JUNCTION OF THE LARGE AND SMALL INTESTINES, TO SHOW THE ILEO-CÆCAL VALVE.
1. Ileum. 2. Cæcum or caput coli. 3. Appendix vermiformis.

The mucous membrane of the large intestine differs considerably from that of the small. There are neither valvulæ conniventes nor villi, but the *glands of Lieberkühn* and the *lymphoid follicles* may be seen studding the mucous membrane (Fig. 220). The follicles are more abundant in the cæcum and in the appendix vermiformis than in any other part of the alimentary canal. The blood-vessels present the same hexagonal arrangement on the surface as that of the stomach. That the mucous membrane of the large intestine may be temporarily used as a substitute for the stomach is proved by the fact of persons having been nourished for many weeks solely by injections. The mucous membrane is lined throughout with columnar epithelium.

Ileo-cæcal Valve.—At the junction of the small with the large intestine the mucous membrane is folded so as to form a valve; but it is not a perfect one, as is proved by pouring water into the large intestine, or by the occasional vomiting of injections. The valve is placed on mesial and dorsal aspect of the cæcum in the adult. The arrangement of the valve is best examined in a dried preparation. The opening is a transverse fissure like a button-hole, and the two flaps are arranged like an upper and a lower eyelid. The upper lid of the valve projects more than the lower, so that the contents of the ileum drop naturally down into the caput coli, where they are apt to collect and form hard lumps. The flaps of the valve consist of mucous membrane and the circular fibres of the ileum. The longitudinal fibres of the ileum are continued directly on to the cæcum;

if these be divided the ileum can be drawn out, and the valve disappears.*

Ileo-cæcal Fossæ. — There are two fossæ, the *anterior* or *ventro-ilco-cæcal fossa* made by a fold of peritoneum commencing on the ventral aspect of the junction of cæcum and ilium and containing the ilio-colic artery. This pouch opens downwards or caudad.

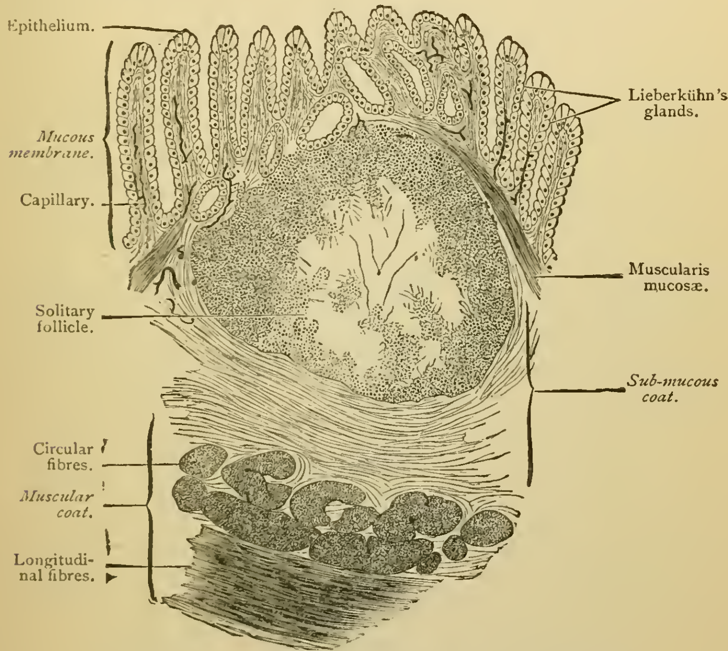


FIG. 220. — LONGITUDINAL SECTION OF THE LARGE INTESTINE.

The *posterior* or *dorsal ilco-cæcal fossa* can be seen by elevating the caput coli, when a fold of peritoneum can be seen passing from its dorsal surface to the caudal margin of the ileum at its junction with the cæcum most remote from the attachment of the iliac mesentery and thence to the appendix. This fossa does not have any blood-vessels in its embrace, but is the larger of the two. Its fossa will admit two fingers, and opens laterally, having the colon to the right and the ileum

* It is interesting to note that the surface of the valve, towards the ileum, is covered with villi; not so the surface towards the large intestine.

mesially. The importance of these fossæ in appendicular troubles and hernia of this region have been brought to the notice of the surgeon.

Folds in the Rectum. — In many subjects we observe that transverse or oblique folds of the mucous membrane project into the rectum. These cannot be seen to advantage unless the bowel be hardened in its natural position. Three, more prominent than the rest, and half an inch (*13 mm.*), or thereabouts, in width, were first pointed out by Mr. Houston.* The lowest of these is found about one inch (*2.5 cm.*) above the anus on the left and posterior portion of the gut; the second on the right and more anterior portion of the gut, about two and a half inches (*6.3 cm.*) above the orifice; while the third is still higher. When thickened or ulcerated, these folds are apt to occasion great pain and obstruction in defæcation.

Arterial Supply of the Alimentary Canal. — The present opportunity is the best for reviewing the arterial supply of, and the anastomoses round, the alimentary canal, from *the mouth to the anus.* Part of the blood supply has been examined in the dissection of the head and neck; part in the dissection of the œsophagus as it passes through the thorax; and the remainder in that of the abdomen. The following table represents the arteries in their order, beginning at the mouth: —

Lower Lip, ...	Submental (deep branch).
	Mental.
	Inferior labial.
	Inferior coronary.
Upper Lip, ...	Superior coronary.
Cheek, ...	Buccal.
	Superior coronary (slightly).
	Facial.
	Transverse facial.
	Infra orbital.
	Superior alveolar.
Mouth, Roof of, ...	Descending palatine.
	Ascending palatine.
	Pharyngeal br. of ascending pharyngeal.
Mouth, Floor of, and Tongue, ...	Artery of the frænum.
	Ranine.
	Sublingual.
	Dorsales linguæ.
	Tonsillar.
	Ascending palatine.
	Ascending pharyngeal.
Epiglottis, ...	Superior laryngeal artery.
Pharynx, ...	Pterygo-palatine.
	Branches of ascending pharyngeal.
	Branches of ascending palatine.
	Superior thyroid.

* *Dublin Hospital Reports*, vol. v., p. 163.

Œsophagus, Cervical, . .	Superior thyroid.
	Inferior thyroid.
Œsophagus, Thoracic, . .	Inferior thyroid.
	Thoracic aorta.
	Gastric.
	Left phrenic.
Œsophagus, Abdominal, .	Gastric.
	Left phrenic.
Stomach, ...	Gastric.
	Pyloric.
	Gastro-epiploica dextra.
	Gastro-epiploica sinistra.
	Vasa brevia.
	Gastro-duodenalis.
Duodenum, ...	Pancreatico-duodenalis superior.
	Pancreatico-duodenalis inferior.
Jejunum, ...	Superior mesenteric.
Ileum, ...	Superior mesenteric.
Cæcum, ...	Colic br. of ileo-colic.
Ascending Colon, ...	Colica dextra.
Transverse Colon, . . .	Colica media.
Descending Colon, . . .	Colica sinistra.
Sigmoid Flexure, ...	Sigmoid arteries.
Rectum, ...	Superior hæmorrhoidal (inferior mesenteric).
	Middle hæmorrhoidal (internal iliac).
	Inferior hæmorrhoidal (internal pudic).
	Arteria sacra media.

DISSECTION OF THE LOWER EXTREMITY.

The body must be placed on its back, with a block placed beneath the buttocks, and the thigh should then be slightly flexed and abducted.

Surface Marking.—The student, before commencing to reflect the skin, should notice the irregularities of the surface which are produced by subjacent structures. The upper part of the thigh is marked off from the abdomen by a more or less well-marked curved furrow, having its convexity downwards. This furrow corresponds with Poupart's ligament, which is attached laterally to the anterior superior iliac spine, and mesially to the spine of the os pubis. The spine of the os pubis can, even in the fattest subject, be distinctly felt, and is a very valuable landmark in the diagnosis between an inguinal and a femoral hernia; for the aperture through which an inguinal hernia emerges is the ventral abdominal ring, situated *above* the spine; the aperture through which a femoral hernia comes out is the saphenous opening, situated *outside* laterad to the spine. On the ventral surface of the thigh is a large triangular depression corresponding with Scarpa's triangle, which has its base at Poupart's ligament. This depression, which is best seen in thin subjects, contains the large vessels and nerves passing down to the leg, the femoral artery being nearly in the centre of the space; a furrow indicating the course of these vessels may be observed extending obliquely down to the mesial surface of the thigh. About three or four inches (*7.5 to 10 cm.*) below the anterior superior iliac spine, there is seen on the outer or lateral surface of the thigh the well-marked prominence of the great trochanter, which is nearly on the same level as the spine of the os pubis. The sartorius can be seen passing obliquely inwards or mesially from the iliac spine, and crossing over the femoral vessels about four inches (*10 cm.*) below Poupart's ligament; in the latter two-thirds of its course it descends nearly vertically. The well-defined ridge, extending from the os pubis to the middle of the femur, when the thigh is abducted, is caused by the adductor longus muscle.

The ventral prominence of the knee is produced by the patella, to which is attached above the tendon of the quadriceps

muscle, and below, the ligamentum patellæ, both of which can be distinctly felt. On each side of the patella is a deep depression, which leads laterally to a rounded prominence, the external condyle; and mesially to the internal condyle, the latter being the larger. The synovial membrane which lines the knee-joint usually extends about two fingers' breadth above the patella, and is a little cephal on the mesial than on the lateral side of the joint.

An incision should be made along the groin, extending from the anterior superior spine of the ilium to the spine of the os pubis; another, from the middle of the first down the ventre of the thigh for about six inches (*15 cm.*). The skin only should be reflected, when the superficial fascia will be exposed.

Superficial Fascia. — The *superficial fascia* varies in thickness, according to the condition of the body. Like other superficial fasciæ, it is divisible into two or more layers, between which are situated the inguinal glands and the cutaneous vessels and nerves. The superficial layer is continuous with that of the abdomen, and becomes firmer below Poupart's ligament, to which, however, it is not connected; the deeper layer is best marked in the upper part of the thigh, especially where it stretches across the saphenous opening, to the margins of which it is closely attached; this portion is called the *cribriform fascia*, and is protruded ventrally by a femoral hernia, forming one of its coverings; this layer is also attached to Poupart's ligament.

The superficial layer of this fascia should now be reflected, by searching for one of the subcutaneous veins (the internal saphena will do) which run between the upper and the deeper layers of the fascia. The cutaneous vessels can thus be traced, and come from the common femoral artery; they are three in number, the *superficial epigastric*, the *superficial external pudic*, and the *superficial circumflexa ilii* arteries. The first ascends over Poupart's ligament to the abdomen (p. 596); the second crosses mesially towards the os pubis; the third passes laterally to the ilium. Each artery is accompanied by one, sometimes by two veins, which empty themselves, either directly into the femoral, or into the great cutaneous vein of the thigh, called the saphena.

Superficial Inguinal Glands. — These glands are easily recognized by their oval form and reddish-brown color. There are two sets: one set runs parallel to Poupart's ligament, and

receives the lymphatics from the skin of the penis, the scrotum, the perineum, the anus, the buttock, the caudal part of the abdominal wall, and the upper and outer, or cephalo-lateral, aspect of the thigh; the outer and lower, or latero-caudal, set lies along the saphena vein, chiefly around the saphenous opening, and receives the lymphatics from the foot, the leg, and the lower, or caudal, part of the thigh. This explains why in cancer of the scrotum and syphilitic disease of the penis the first set becomes enlarged; and the second, in diseases of the extremity.

Fig. 221.—Lymphatic Vessels and Glands of the Groin.

The lymphatic vessels which pass to and from the glands are small, and may escape observation, unless specially looked for. They all pass through the femoral ring into the abdomen, and eventually empty themselves into the receptaculum chyli.

The glands mentioned in the preceding paragraph are all superficial. There are others, more deeply seated, close to the great vessels of the thigh; these are much smaller, and sometimes cannot be found.

Superficial Arteries of the Groin.—The *superficial epigastric* artery comes through the fascia lata, sometimes through

the saphenous opening, half an inch (*13 mm.*) pedad to Poupart's ligament. It ascends over Poupart's ligament to pass to the subcutaneous tissue of the abdomen, as far as the umbilicus, and supplies the inguinal glands, and anastomoses with the deep epigastric and internal mammary arteries. Its further course is described at p. 420.

The *superficial circumflexa ilii* emerges through the fascia lata, runs parallel to Poupart's ligament towards the crest of the ilium, and ends in the subcutaneous tissue and inguinal glands. It anastomoses with the deep circumflex iliac, the gluteal, and the ascending branches of the external circumflex arteries.

The *superficial external pudic* comes through the saphenous opening, crosses over the spermatic cord, and supplies the penis and scrotum in the male, and the labium in the female. This artery is usually divided in the operation for femoral hernia, also in that for phymosis, since it runs along the penis to supply the prepuce. Arising directly from so large an artery as the femoral, it sometimes bleeds profusely; for it is an admitted fact that when even a small branch, coming directly from a principal artery, is divided near its origin, it will sometimes pour out as much blood as if an opening were punched out of the trunk as large as the area of the divided branch.* There is another pudic artery, called the *deep external pudic:* this runs between the fascia lata and the pectineus, supplying that muscle, the scrotum in the male, and the labium in the female. They both anastomose with branches of the internal pudic artery.

The incision should be prolonged down the thigh, over the knee, to the tubercle of the tibia. The skin must then be reflected, to expose the subcutaneous tissue over the whole ventral aspect of the thigh. The cutaneous vessels and nerves should be looked for in the subcutaneous fat in the following situations: on the *mesial side* are the inguinal branch of the ilio-inguinal nerve passing down through the *external or ventral* abdominal ring, mesial to the saphenous opening; *lower down* are the two branches of the internal cutaneous nerve supplying the skin on the mesial aspect of the thigh as far as the knee, the lower branch accompanying the internal saphena vein which ascends

* Mr. Liston had occasion to tie the external iliac artery for a supposed injury (by a pistol-ball) to the femoral. It was discovered, after the death of the patient, that the ball had injured only one of the superficial branches of the femoral about an inch from its origin. See his paper in the *Med. Chir. Trans.*, vol. xxix., 1846.

to pierce the saphenous opening; there are also low down some filaments from the long saphena nerve; on the *ventral aspect* of the thigh there is found the crural branch of the genito-crural nerve, and lower down, as far as the knee, are the middle cutaneous nerves; on the *outer or lateral side* are seen filaments of the external cutaneous nerve.

Internal Saphena Vein. — This is the chief subcutaneous vein of the lower limb. Its roots, arising from the inner or

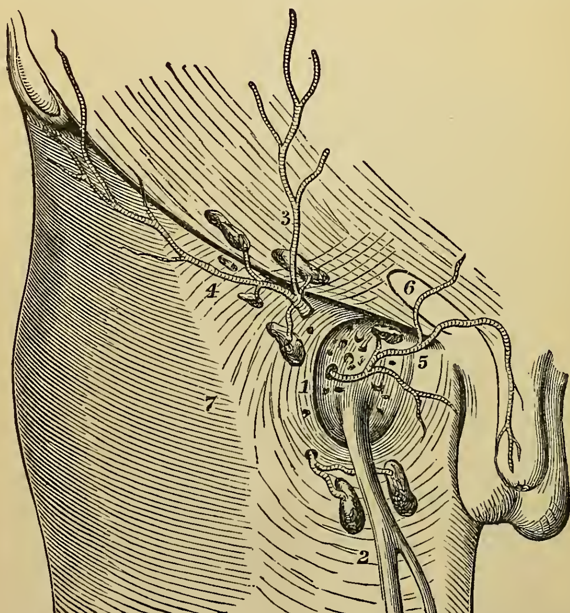


Fig. 222. — Superficial Vessels and Glands of the Groin. Saphenous Opening with the Cribriform Fascia.

1. Saphenous opening of the fascia lata. 2. Saphena vein. 3. Superficial epigastric a. 4. Superficial circumflexa ilii a. 5. Superficial pudic a. 6. External abdominal ring. 7. Fascia lata of the thigh.

mesial side of a venous arch on the dorsum of the foot, unite into a single trunk, which ascends in front of the inner ankle, along the inner *or mesial* side of the leg, behind or dorsad to the knee, along the inner and front part of the thigh, where it passes through an opening — the *saphenous opening* — in the fascia lata, to join the femoral vein, immediately dorsad to the crural arch (Fig. 222). In this long course it receives many tributary veins, some of which are often large, especially one

which, coursing round the inner or mesial part of the thigh, is frequently as large as the main trunk. Just before its termination it is joined by the superficial veins, which accompany the arteries of the groin, already alluded to. Like all subcutaneous veins, it is provided with valves, chiefly where joined by other veins, to support the column of the blood.

Cutaneous Nerves. — The distribution of the cutaneous nerves of the thigh varies considerably, but they are always found more abundantly on the inner or mesial than on the outer or lateral aspect of the thigh. The nerves are divided into *external*, *middle*, and *internal*. All directly or indirectly proceed from the lumbar plexus, and, perforating the fascia lata, divide in the subcutaneous tissue.

a. The *external cutaneous nerve* is a branch of the second and third lumbar nerves. It enters the thigh dorsad to Poupart's ligament close to the anterior superior spine of the ilium. Here it divides into two branches, an anterior *or ventral*, and a posterior. The *anterior* branch comes through the fascia lata about four inches (*10 cm.*) below Poupart's ligament, and can be traced down the outer side of the thigh as far as the knee, giving off numerous branches. The *posterior* branch, after coming through the fascia lata, divides into filaments, which are distributed to the skin over the nates and the dorsum of the thigh.

b. The *middle cutaneous nerves*, one or two in number, are given off by the anterior crural in the thigh. They pass through the sartorius about four inches (*10 cm.*) below Poupart's ligament, perforate the fascia lata, and descend along the ventral and mesial part of the thigh as far as the knee, distributing branches on either side, some of which communicate with the long saphenous nerve. In its course along the front *or ventral aspect* of the thigh it joins with the crural branch of the genito-crural and the internal cutaneous nerves.

c. The *internal cutaneous nerve*, also a branch of the anterior crural, crosses obliquely over the sheath of the femoral artery. It then divides into two branches, an anterior and an internal; the *anterior branch* comes through the fascia lata in the lower third of the thigh, where it terminates in two branches, one being distributed to the inner side of the knee, the other crossing over the patella to the outer side of the joint; the *internal branch* perforates the fascia lata just above the knee-joint, after running down along the dorsal border of the sartorius, and supplies the integument on the mesial side of the leg. Whilst still beneath the fascia lata, the internal cutaneous nerve unites below the adductor longus in a plexiform manner with the long saphenous and obturator nerves.*

d. The *crural branch* of the *genito-crural nerve* perforates the ventral layer of the sheath of the femoral vessels, comes through the fascia lata immediately below Poupart's ligament, and supplies the skin on the ventral aspect of the thigh. About two or three inches (*5 to 7.5 cm.*) below the crural arch it usually communicates with the middle cutaneous nerve. It also distributes a few filaments to the femoral artery in its passage under the crural arch.

e. The *inguinal branch* of the *ilio-inguinal nerve*, after emerging from the external abdominal ring, supplies the skin on the inner aspect of the upper third of the thigh.

* It is important to note that one, sometimes two, of these branches of the internal cutaneous crosses the sheath of the femoral artery, just where the sartorius begins to overlap it, and therefore at the spot where it is usually tied. See diagram, p. 573.

Fascia Lata. — Remove the subcutaneous fat and the deeper layer of the superficial fascia, to examine the dense white fascia — the *fascia lata* — of the thigh. The use of this fascia is to cover the muscles of the thigh collectively, and to form separate sheaths for each; so that it not only keeps them together, but maintains each in its proper position. A knowledge of these sheaths is important, because they interfere with the progress of deep-seated matter towards the surface, and cause it to burrow in this or that direction according to the part in which it forms.

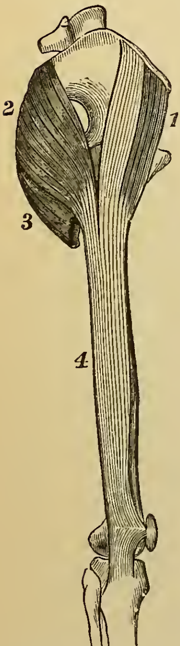


Fig. 223. — Fascia on the Outside of the Thigh.

1. Tensor fasciæ femoris. 2. Gluteus maximus. 3. Lower fibres of ditto. 4. Fascia lata.

The fascia is not of equal strength all round the thigh. It is comparatively thin on the inner side; exceedingly thick and strong down the outer side; here, indeed, it has the appearance of a dense expanded aponeurosis, strapping down the vastus externus muscle, and is sometimes called the *ilio-tibial band;* and it certainly performs the office of a tendon, for it gives insertion between its two layers to two powerful muscles, — namely, the tensor fasciæ femoris, and the gluteus maximus (Fig. 223).

The fascia lata is attached to the margin of the bones which constitute the framework of the lower extremity. Beginning from above, its attachment can be traced from the dorsal surface of the sacrum and coccyx, along the crest of the ilium, thence along Poupart's ligament to the body of the os pubis and the linea ilio-pectinea, and along the rami of the os pubis and ischium. Proceeding down the thigh, it penetrates on each side of the limb to the linea aspera, forming what are called the *external* and *internal intermuscular septa;* the lateral one, the stronger, separates the vastus externus anteriorly from the short head of the biceps, both of which have origin from the fascia; the mesial one separates the vastus internus ventrally from the adductor muscles dorsally. Below, it can be traced round the knee-joint, and is particularly strong, especially on the outer side, where it is attached to the head of the tibia and fibula, and forms the insertion of the tensor fasciæ

femoris. The fascia lata is very strong over the gluteus medius — the *gluteal aponeurosis* — and at the upper border of the gluteus maximus divides into two layers, one superficial to the muscle, the other deep, which separates this muscle from the deeper muscles, and becomes connected with the great sacro-sciatic ligament. The fascia lata also furnishes thinner sheaths for the separate muscles.

There are numerous small apertures in the fascia, through which the cutaneous nerves and vessels are transmitted; but the most important one is the large opening — the *saphenous opening* — through which the saphena vein passes to join the femoral. The part of the fascia situated external to the saphenous opening is termed the iliac portion of the fascia lata; that internal to it, the pubic portion.

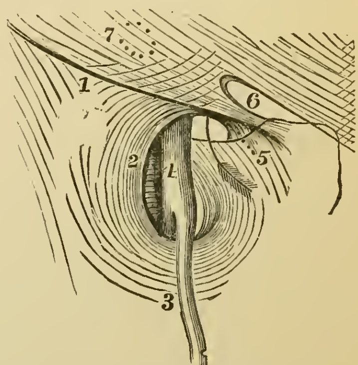


Fig. 224.— Diagram of the Femoral Ring and the Saphenous Opening.

(The arrow is introduced into the femoral ring.)

1. Crural arch. 2. Saphenous opening of the fascia lata. 3. Saphena vein. 4. Femoral vein. 5. Gimbernat's ligament. 6. External abdominal ring. 7. Position of the internal ring in dotted outline.

The *iliac portion* is attached to the crest of the ilium, to the whole length of Poupart's ligament, and, in conjunction with Gimbernat's ligament, to the linea ilio-pectinea; from this attachment it arches downwards and outwards, its inner margin forming the outer falciform edge of the saphenous opening; this border passes over the anterior sheath (formed by the transversalis fascia) of the femoral artery, and is seen to be continuous below with the *pubic portion*, which can be traced upwards over the pectineus and adductor longus muscles, behind the posterior sheath (formed by the iliac fascia) of the femoral vessels, where it is connected with the sheath of the iliacus and psoas muscles and the fibrous structures of the hip-joint. Above, it is attached to the linea ilio-pectinea, to the body and the ramus of the os pubis.

Saphenous Opening in the Fascia Lata. — The *saphenous opening* is an oval aperture in the fascia lata, immediately below the crural arch, on the inner side of the front aspect of the thigh, through which the saphena vein passes to join the femoral. There is no definite border to the saphenous opening

until the fascia — *cribriform*, which covers the opening and blends with its margin — has been removed. It is situated just below the crural arch and external to the spine of the os pubis; it is oval, with the long axis vertical, and is about one inch and a half (*3.8 cm.*) long and an inch (*2.5 cm.*) broad. Its border on the inner side is not defined; for here the fascia lata ascends under the femoral vessels, and is continuous with the iliac fascia of the pelvis.* But the outer or iliac border is clearly defined. This lies in front of the femoral vessels, is crescent-shaped, with the concave upper end towards the os pubis, and is called the *falciform process*, whilst its deeper fibres are known as *Burns' ligament*. The lower horn of the crescent curves under the saphena vein with a well-defined border, and on being traced upwards becomes less well-marked until it is gradually lost in the fascia on the inner side of the opening. The upper horn, *Hey's ligament*,† arches over the femoral vein, and then descending slightly is continued uninterruptedly into Gimbernat's ligament — *i.e.*, into that part of the crural arch which is inserted into the linea ilio-pectinea. The upper horn deserves especial attention, because it forms the upper boundary of the aperture through which a femoral hernia takes place; and, being chiefly concerned in the constriction of the rupture, must be divided for its relief. This may be easily ascertained by introducing the little finger under the crural arch, on the inner side of the femoral vein — in other words, into the femoral ring (see the arrow, Fig. 224). Feel how the upper horn of the crescent would gird the neck of a hernia, and that its tension is greatly influenced by the position of the limb; for if the thigh be bent and brought over to the other side, the tension of all the parts is materially lessened.‡

Cribriform Fascia. — The *cribriform fascia* is so called because it is perforated with numerous apertures for the passage of the superficial vessels and lymphatics. It is a thin membranous covering over the saphenous opening, and is prolonged from

* On the inner or mesial side of the femoral vessels the pubic portion of the fascia is attached to the linea ilio-pectinea.

† The upper horn is sometimes called *Hey's Ligament*, after the surgeon who first drew attention to it. (*Observations in Surgery*, by W. Hey, F.R.S., London, 1810.)

‡ We must always bear in mind that, though the crural arch and the fascia attached to it have received particular names, they are not, on that account, distinct and separate; but all are intimately connected, and portions merely of one continuous expansion. Thus all the parts are kept in a condition of mutual tension, which depends very much on the position of the thigh.

the outer edge of the opening over the sheath of the femoral vessels, and adheres on the inner side to the fascia lata, covering the pectineus muscle. Some anatomists describe this fascia as a portion of the deeper layer of the superficial fascia ; others consider it as a thin prolongation of the fascia lata itself across the opening. Its chief surgical importance is derived from the fact that it forms one of the coverings of a femoral hernia.

The cribriform fascia must now be removed on one side so as to display the saphenous opening, which will appear as represented in Fig. 224.

ANATOMY OF THE PARTS CONCERNED IN FEMORAL HERNIA.

The anatomy of the parts concerned in the femoral hernia cannot be thoroughly understood without the assistance of special dissections. The following demonstration therefore takes for granted that the student has the opportunity of seeing the parts, not only on their femoral, but also on their abdominal side.

The different parts of the subject should be examined in the following order : —

a. The formation of the crural arch.

b. The arrangement of the parts as they pass dorsad to the arch.

c. The sheath of the femoral vessels.

d. The crural canal and ring.

e. The practical application of the subject.

Poupart's Ligament or Crural Arch. — The lower border of the aponeurosis of the external oblique muscle extends from the anterior superior spine of the ilium to the spine of the os pubis, and forms over the bony excavation beneath the *crural arch* or *Poupart's ligament.* (It is marked by the dark line in Fig. 224.) The direction of the arch is at first somewhat oblique, but towards its inner half becomes nearly horizontal. In consequence of its intimate connection with the fascia lata of the thigh, the line of the arch describes a gentle curve with the convexity downwards. The arch is attached to the spine of the os pubis, and also for some distance along the linea ilio-pectinea (Fig. 224). This additional attachment, called *Gimbernat's ligament,* is of importance, for it is frequently the seat of stricture in femoral hernia.

Gimbernat's Ligament. — The best view of Gimbernat's ligament is obtained from within the abdomen, it being only necessary to remove the peritoneum. It is that portion of the aponeurosis of the external oblique muscle which is inserted into the linea ilio-pectinea for about an inch (*2.5 cm.*) in length. It is placed nearly horizontally in the erect posture, and is triangular with its apex at the os pubis and its base directed outwards. In front, it is continuous with the crural arch; behind, it is inserted into the linea ilio-pectinea; externally it is continuous with the fascia lata through Hey's ligament (Fig. 224). Its length is from three-quarters of an inch to one inch (*18 mm. to 2.5 cm.*); but it is usually longer in the male than in the female.

On putting your finger into the femoral ring, you feel the sharp and wiry edge of this ligament; observe, too, that as the body lies on the table, the plane of the ligament is perpendicular, and therefore that it *recedes from the surface.*

An incision should now be made through the fascia lata along the entire length of Poupart's ligament; another also through the fascia vertically, from the anterior superior iliac spine down the thigh for about four inches (*10 cm.*), and the fascia lata carefully dissected downwards and inwards from the subjacent structures. This will expose the structures as they pass under or dorsad to Poupart's ligament to the ventral aspect of the thigh.

Arrangement of the Parts which pass dorsad to the Arch. — The crural arch transmits from the abdomen into the thigh (proceeding in order from the outer side) the following objects shown in Fig. 225: 1. The external cutaneous nerve. 2. The iliacus with the anterior * crural nerve lying on it near its inner border. 3. The femoral artery resting on the psoas muscle. 4. The crural branch of the genito-crural nerve. 5. The femoral vein. 6. The crural sheath surrounding the femoral vessels, formed ventrally by the fascia transversalis, dorsally by the fascia iliaca. 7. The lymphatics passing upwards through the femoral canal. 8. The pectineus. These muscles and vessels fill up the space beneath or dorsad to the crural arch, except on the inner side of the femoral vein, where a space is left for the passage of the lymphatics: this is called the *crural*

* It would be as well to omit any locative word in regard to this nerve, as it is single, and designates the part supplied, hence *crural* is all that is necessary. — A. H.

or *femoral ring.* The muscles are separated from the vessels by a strong vertical fibrous partition passing from the arch to the bone, which is nothing more than a continuation of the sheath of the psoas. The artery, too, is separated from the vein by a similar, although a much weaker partition, and there is a third close to the inner side of the vein. These three partitions not only keep all the parts in their right place, but bind the arch to the bone, and prevent its being uplifted by any protrusion between it and the muscles and vessels. This, coupled with the close attachment of the fascia iliaca to the crural arch, explains

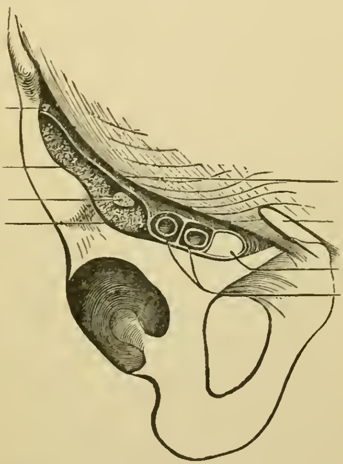


Fig. 225.—Position of Parts under the Crural Arch (Vertical Section).

why femoral hernia rarely takes place in any other situation than on the inner side of the femoral vein.*

Sheath of the Femoral Vessels.—The femoral vessels descend beneath to the crural arch, enclosed in a funnel-shaped membranous sheath. This sheath appears to be derived immediately from the arch itself, but it is really formed *in front or ventrally* by a prolongation from the fascia transversalis of the abdomen. This prolongation, uniting with the continuation from the fascia iliaca (to join the fascia lata) *behind or dorsad to* the femoral vessels, forms a funnel, with the wide

* If the partitions from any cause yield, or become slack, then a rupture may descend in front of the vessels, or even (though this is rare) on the outer or lateral side of the artery.

part uppermost, into which the femoral vessels enter. This is the funnel-shaped sheath of the femoral vessels.

The fascia transversalis, descending over the femoral vessels, forms the *front or ventral part* of their sheath; the *hind or dorsal part* of the sheath is formed by the fascia iliaca, which runs down behind or dorsad to the vessels to join the pubic portion of the fascia lata. The sheath descends as low as the lower horn of the saphenous opening, where it is gradually lost upon the cellular coat (tunica adventitia) of the femoral vessels. The outer part of the sheath, in front, is perforated by the crural branch of the genito-crural nerve, and the superficial arteries of the groin; the inner part, by the saphena vein and some lymphatic vessels.

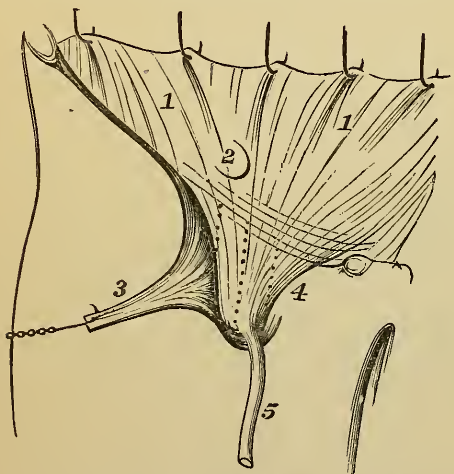


Fig. 226. — Diagram of the Sheath of the Femoral Vessels.

1. 1. Fascia transversalis. 2. Internal or dorsal ring. 3. Crural arch reflected. 4. Sheath of the femoral vessels. 5. Saphena vein.

The sheath of the femoral vessels is divided into three compartments separated from each other by partitions: the outer is occupied by the femoral artery; the middle by the femoral vein; the inner is the crural canal, into which a femoral hernia descends.

The *deep crural arch* is the thickened band of fibres connected with the front or ventral aspect of the crural sheath; the fibres run in the same direction as the crural arch, but quite independently of it, as shown in Fig. 226; these bands lie over the neck of the sac of a femoral hernia, and are often the seat of the stricture.

Practically, the sheath is important for many reasons: —

1. A femoral hernia descends within it. 2. It constitutes, therefore, one of the coverings, *fascia propria*, of the hernia. 3. It contains within its substance the *deep crural arch*, which not infrequently forms the stricture of a femoral hernia, and has, therefore, to be divided before the intestine can be returned.

Crural Canal and Femoral Ring. — The hollow, dorsad to

the crural arch, is completely occupied by the structures before mentioned, except for a small triangular space, forming the inner compartment of the femoral sheath, called the *crural canal.* The canal is on the inner side of the femoral vein, and is from a quarter to half an inch (*6 mm. to 13 mm.*) in length. Its base commences above in the femoral ring, and its apex ends below the saphenous opening. *In front* it has Poupart's ligament and the falciform process of the iliac portion of the fascia lata, and is formed by the fascia transversalis; *behind* it is formed by the fascia iliaca; *internally* it is formed by the junction of the fascia transversalis and the fascia iliaca, and is in relation with the base of Gimbernat's ligament; *externally* it is separated from the femoral vein by the septum of fascia which divides the middle from the inner compartment of the crural sheath.

The *femoral ring* is the upper opening of the crural canal, and is bounded, *in front* by the superficial and deep crural arches; *behind* by the horizontal ramus of the os pubis, the pectineus, and the pubic portion of the fascia lata; on the *outer side*, by the fascial septum separating it from the vein; on the *inner side*, by the thin, wiry edge of Gimbernat's ligament, the conjoined tendon of the internal oblique and transversalis, the fascia transversalis, and the fibres of the deep crural arch. In the undisturbed condition of the parts there is no gap; it is only a weak place, which, when a hernia escapes through it, feels like a ring: hence the name of *femoral ring.**

The femoral ring is surrounded on all sides by unyielding structures. This accounts for the little benefit afforded by the warm bath in cases of strangulation. Sir W. Lawrence was in the habit of saying that he never saw a strangulated femoral hernia where the warm bath was of any avail.

Practical Application of the Subject. — From what has been said, the student ought now to understand — 1, at what aperture a femoral hernia escapes from the abdomen; 2, the course which it takes, and its relations to the surrounding parts; 3, the proper mode of attempting the reduction; 4, the structure and arrangement of its coverings; and 5, the probable seat of stricture.

* The femoral ring is naturally occupied by a little fat and cellular membrane, by lymphatic vessels, and often by a small lymphatic gland. But we have never met with anything deserving the name of a diaphragm or membranous septum, such as is described by Cloquet as the *septum crurale*, and is, surgically, of no importance.

The hernia escapes from the abdomen through the femoral ring — that is, under or dorsad to the weak part of the crural arch, between the femoral vein and Gimbernat's ligament. Here is the mouth of the hernial sac, or that part of it which communicates with the abdomen. It descends for a short distance nearly perpendicularly, and projects as a small tumor in front of or ventrad to the pectineus muscle. Its progress downwards, however, is soon arrested, partly by the very close adhesion of the subcutaneous structures to the lower margin of the saphenous opening; partly by the flexion of the thigh. Consequently, if the hernia increases in size, it usually rises over or becomes ventrad to the crural arch, where the subcutaneous tissue offers less resistance; and the bulk of the hernia extends outwards towards the ilium, assuming more or less of an oblong form, with the long axis parallel to the crural arch. Since, then, the body of the hernia forms a very acute angle with the neck, the right mode of attempting its reduction is to draw it, first down from the groin, and then to make pressure on it backwards in the direction of the femoral ring.

Coverings of a Femoral Hernia. — The *coverings* of a femoral hernia are as follows: It first protrudes before it the *peritoneum,* technically called the hernial sac.* The sac is covered by more or less fat, according to the condition of the patient, called the *subperitoneal fat.* It next pushes before it the *sheath* of *the femoral vessels,* which forms an investment more or less thick. In front of this is the *cribriform fascia.* Lastly, there is the *subcutaneous tissue* and *skin.*

Seat of Stricture. — The *seat of stricture* is usually at the femoral ring, and the position of the neighboring blood-vessels indicates that the proper direction in which to divide the stricture is either directly inwards, through Gimbernat's ligament, as recommended by Sir W. Lawrence, or upwards, through Hey's ligament, as recommended by Sir A. Cooper.† There is no risk of wounding an artery, supposing the vessels to take their ordinary course. But it occasionally happens (Fig. 227) that the obturator artery runs *above* (in the re-

* In some cases the fascia propria so much resembles the hernial sac that it is not easy to distinguish between them. Generally speaking, they are separated by a small quantity of fat.

† The operation recommended by Sir A. Cooper is that usually performed now; because, if Gimbernat's ligament be divided, its cut edges often retract to such an extent that no truss can possibly retain the hernia when the patient assumes the erect posture.

cumbent position) the femoral ring; in such a case, the neck of the sac would be encircled by a large blood-vessel. From the examination of two hundred bodies, the chances are about seventy to one against this unfavorable distribution. But the possibility of it has given rise to *this rule* in practice — not to cut deeply in any one place through the stricture, but rather to notch it in several. By this proceeding we are much less likely to wound the abnormal artery, because it does not run at the base of Gimbernat's ligament, but about $\frac{1}{8}$ of an inch (*3 mm.*) from the margin of it.

Such is an outline of the anatomy of the parts concerned in a femoral hernia. The normal anatomy in each case being similar, it might be supposed that all operations for the relief of

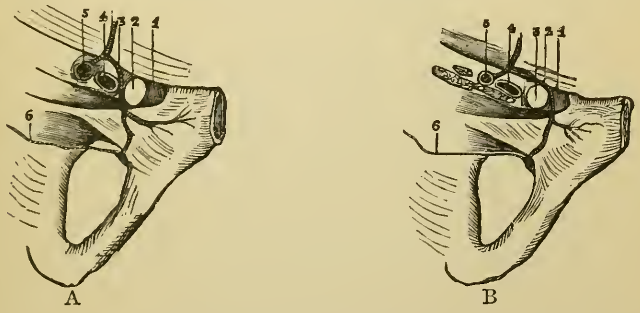


FIG. 227. — VIEW OF THE DIFFERENT DIRECTIONS WHICH AN ABNORMAL OBTURATOR ARTERY MAY TAKE. (SEEN FROM ABOVE.)

A. 1. Gimbernat's Ligament. 2. Femoral ring. 3. Abnormal obturator artery. 4. External iliac vein. 5. External iliac artery. 6. Diminutive obturator artery arising from its normal source. B. 1. Gimbernat's ligament. 2. Abnormal obturator artery. 3. Femoral ring. 4. External iliac vein. 5. External iliac artery. 6. Diminutive obturator artery.

this kind of hernia would be straightforward and pretty much alike; but this is very far from being the case; indeed, surgeons agree that they never operate without the expectation of meeting some peculiarity.

Dissection. — The fascia must now be removed from the front aspect of the thigh without disturbing the subjacent muscles from their relative positions. The mass of muscles on the inner side of the thigh consists of the adductors; that in the middle, of the extensors; the long thin muscle crossing the ventral aspect obliquely from the outer to the inner side is the sartorius. In the middle are seen the femoral vessels, and the crural nerve emerging beneath the crural arch.

Sartorius. — This, a narrow, flat muscle (Fig. 228), *arises*

from the anterior superior spine of the ilium, and from the ridge below to the extent of an inch (*2.5 cm.*). It passes obliquely like a strap over the front aspect of the thigh towards the inner side, and then descends almost perpendicularly on the inner side of the thigh as far as the knee, where it terminates in a flat tendon which expands, and is *inserted* into the inner and front part of the tibia just below its tubercle. The tendon appears all the wider on account of its broad connection with the fascia of the leg, which extends pedad to the internal malleolus. The broad insertion of this muscle lies anterior and covers the tendinous insertions of the gracilis and semi-tendinosus, and between them is a bursa. A large bursa * is interposed between the tendon and the internal lateral ligament. The chief *action* of the muscle is to fix the pelvis steadily on the thigh. It first bends the leg upon the thigh, and then bends the thigh upon the abdomen, abducting and slightly rotating it laterally. It crosses one leg over the other, as tailors sit when at work. If the leg be the fixed point, it will bend the trunk upon the thigh and rotate the pelvis inwards. Its nerve comes from the middle cutaneous branch of the crural.

Scarpa's Triangle. — In consequence of the oblique direction of the upper or cephal third of the sartorius, a triangle is formed, which has this muscle and the adductor longus for its two sides, and the crural arch for its base; the triangle is called *Scarpa's.*†

Its floor or dorsal aspect is formed by the iliacus, the psoas, the pectineus, and the abductor longus, with sometimes the adductor brevis between the borders of the two latter muscles. The contents of this important space should be carefully displayed, and their relative positions well studied. This triangle contains all the parts which pass under or dorsad to the crural arch, namely, from without inwards, the external cutaneous nerve, close to the anterior spine of the ilium; the iliacus and psoas; the crural nerve and its divisions, especially the long saphenous nerve; the crural branch of the genito-crural nerve, the common femoral artery with its two large divisions, the superficial femoral and the profunda, which run down, nearly parallel to each other, the latter being the more external and

* In persons, females especially, who are in the habit of riding, this bursa sometimes becomes enlarged.

† So called in compliment to the Italian anatomist who first tied the femoral in it for popliteal aneurism.

giving off the internal and external circumflex arteries; the femoral vein, joined by the profunda vein and the long saphena, and the pectineus muscle with the deep external pudic artery.

The triangle is important in a surgical point of view, since it is in this space that the femoral artery is usually ligatured for popliteal aneurism. The guide to the artery is the inner border of the sartorius. The situation at which this muscle crosses over the femoral artery varies from one and a half to four and a half inches (*3.8 to 11.3 cm.*) below to Poupart's ligament; so that no rule can be laid down as to the exact situation where the artery disappears beneath or dorsad to the sartorius. The best way to find the inner border of the muscle during life is to make the patient put it in action.

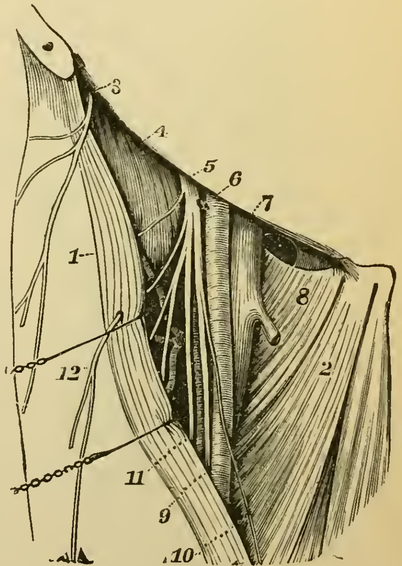


FIG. 228. — DIAGRAM OF SCARPA'S TRIANGLE. 1. Sartorius. 2. Adductor longus. 3. External cutaneous n. 4. Iliacus internus. 5. Anterior crural n. 6. Femoral artery. 7. Femoral vein. 8. Pectineus. 9. Long saphenous n. 10. Internal cutaneous n. 11. Nerve to vastus internus. 12. Middle cutaneous n.

Adductor Muscles. — A strong group of muscles, called the *adductors*, extends along the inner side of the thigh, from the pelvis to the femur. Their two most important actions are to cooperate in balancing the pelvis steadily on the thigh, as in standing on one leg, and (if the fixed point be reversed) to draw together or adduct the thighs, at the same time rotating the thigh externally and internally. They are five in number, and are supplied, with one exception — the pectineus — by the same nerve, namely, the obturator. They are termed, respectively, the gracilis, adductor longus, pectineus, adductor brevis, and adductor magnus. The innermost, or most-mesial, is the gracilis; to clean it properly it should be stretched by separating one thigh from the other.

Gracilis. — This long, flat muscle *arises* by a broad, ribbon-like tendon two or three inches (*5 to 7.5 cm.*) in breadth, from

the os pubis close to the symphysis, and from the inner margin of the rami of the os pubis and ischium (Fig. 229). It descends almost perpendicularly on the inner side of the thigh, and terminates in a thin, round tendon which subsequently spreads out

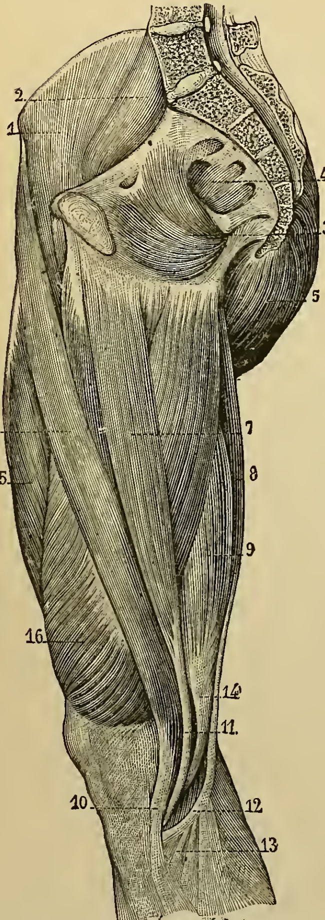


FIG. 229.—INTERNAL OR MESIAL MUSCLES OF THE THIGH.

1. Iliacus. 2. Psoas magnus. 3. Obturator internus or dorsalis. 4. Pyramidalis. 5. Gluteus maximus. 6. Sartorius. 7. Gracilis. 8. Semi-tendinosus. 9. Semi-membranosus. 10. Tendon of the sartorius and its fibrous expansion. 11. Tendon of the gracilis. 12. Tendon of the semi-tendinosus. 13. Common fibrous expansion. 14. Tendon of the semi-membranosus. 15. Rectus femoris. 16. Vastus internus.

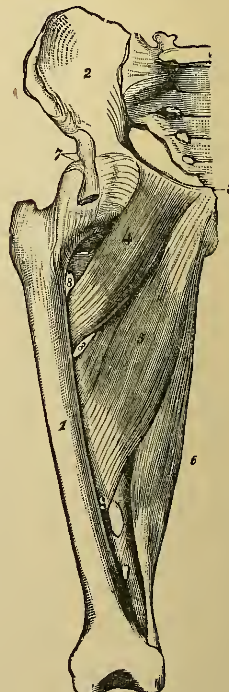


FIG. 230.—PECTINEUS AND ADDUCTORS.

1. Femur. 2. Os innominatus. 3. Pubis. 4. Pectineus. 5. Adductor longus. 6. Lower or long portion of the adductor magnus. 7. Tendon of origin of the rectus femoris. 8. Vascular foramina. 9. Hunter's canal.

and is *inserted* into the inner side of the upper part of the tibia below to the tubercle, immediately behind or dorsad to the sartorius and above to the semi-tendinosus. The tendon plays over the internal ligament of the knee-joint, and there is a bursa common to it and the semi-tedinosus to diminish friction. This muscle assists in fixing the pelvis and in adducting the thigh; it further helps to bend the knee. The action of this muscle differs slightly in the vertical and the horizontal positions. *Vertical:* external rotation, adduction, flexion, external rotation with knee flexed at 90°; adduction with knee flexed 90°, flexion with knee flexed 90°. Its nerve comes from the anterior division of the obturator.

Horizontal: femur flexed 90°: adduction, internal rotation. External rotation by lowering the femur two or three inches. Extension adduction with knee flexed 90°. External rotation with knee flexed 90°. Extension with knee flexed 90°.*

Adductor Longus. — This triangular muscle lies between the gracilis and the pectineus, and *arises* by a round tendon from the front or ventral surface of the body of the os pubis below or caudad to the crest (Fig. 230). As it descends, the muscle becomes broader, and passing downwards, outwards, and backwards, is *inserted* by a broad aponeurosis into the middle third of the inner margin of the linea aspera of the femur. It forms with the sartorius the triangular space called Scarpa's triangle, above described. It rests upon or is ventrad to the adductor brevis and magnus, the profunda vessels, and the anterior branches of the obturator vessels and nerve. The *action* of this muscle in the *vertical line*, that is with *femur vertical*, is that of external rotation, adduction, and flexion. *Horizontal:* flexed at 90° adduction: external rotation and extension. It is femur supplied by the anterior division of the obturator nerve.

Pectineus. — This muscle lies on the same plane, but external or laterad to the adductor longus, from which it is separated by a slight interval, in which may be seen the adductor brevis and the anterior or ventral division of the obturator nerve (Fig. 230). It *arises* from the linea ilio-pectinea, from the triangular surface of the os pubis in front of or ventrad to the line, and from the fascial prolongation of Gimbernat's ligament covering the muscle; it passes downwards, outwards, and backwards, or

* Phila. Med. Jour. Prize contest I. 1. 99. Rotators of the Femur and their other Functions, by Eb. W. Thomas, M.D., Philadelphia.

caudo-latero-dorsad, and is *inserted* into the upper or cephal part of the ridge leading from the lesser trochanter to the linea aspera. It lies upon the capsular ligament of the hip-joint, the adductor brevis, the obturator vessels and nerve, and the obturator externus or ventralis. The *action* must be considered in four stages: *femur vertical; horizontal or femur flexed* 90°; *in extreme flexion;* and *during flexion.*

Femur Vertical.—The muscle is an *external rotator*, but 20° of *internal rotation* it becomes neutral in its action, and if this internal rotation is increased it becomes just as powerful an internal rotator; *adductor; flexor.*

Horizontal, femur flexed 90°: *adductor, external rotator, flexor;* in this position, however, the muscle has almost ceased to act as a flexor, and exerts all its force in adduction and external rotation.

In Extreme Flexion.—The insertion being on a more superior plane than the origin, the muscle becomes an *extensor.*

During Flexion.—If this action commences with the extremity *rotated externally*, and ending at 90° flexion as an *external rotator*, the same function is performed throughout flexion. But if flexion be preceded by *internal rotation* beyond *20°* it will remain an *internal rotator* until flexion reaches 90°, when it will suddenly change to an external rotator. Its nerve comes from the crural which runs under or dorsad to the femoral vessels to enter it close to its outer border; sometimes also from the obturator, and the accessory obturator if present (p. 488).

By separating the contiguous borders of the pectineus and the adductor longus, the adductor brevis is exposed with the anterior division of the obturator artery and nerve lying upon it. To obtain a complete view of it, the pectineus and adductor longus must be reflected from their origins and turned downwards. The obturator nerve supplies all the adductors. It leaves the pelvis through the upper part of the obturator foramen, and soon divides into an anterior and posterior branch; the *anterior* runs in front of or ventrad to the adductor brevis and supplies the hip-joint, the adductor longus, the gracilis, and sometimes the adductor brevis and the pectineus; the *posterior* runs behind to the adductor brevis, and supplies it as well as the obturator externus, the adductor magnus, and the knee-joint.

The student should now, before the parts are disturbed, examine the femoral artery as it passes down along the centre of

Scarpa's triangle; its further course will be described later on, as well as the branches which come off from it.

Course and Relations of the Femoral Artery. — The *femoral artery* is a continuation of the external iliac. Passing beneath or dorsad to the crural arch at a point midway between the spine of the ilium and the symphysis pubis, it descends along the front and inner or ventro-mesial side of the thigh. At the junction of the upper two-thirds with the lower third of the thigh, it passes through an opening in the tendon of the adductor magnus, and, entering the ham, takes the name of popliteal. A line drawn from the point indicated, of the crural arch to the adductor tubercle on the internal condyle, corresponds with the course of the artery. Its distance from the surface increases as it descends. Immediately under, and for a short distance below, pedad to the crural arch, it is supported by the inner border of the psoas; lower down or more pedad it runs in front of the pectineus, but separated from it by the profunda vessels; still lower down it lies upon the adductor longus, and then upon the adductor magnus.

That part of the artery which extends from the crural arch to the giving off of the profunda is called the common femoral artery; its continuation beyond the profunda is termed the superficial femoral; and it is the latter vessel which is ligatured for aneurism of the popliteal artery.

In the *upper third of the thigh*, the artery is situated in Scarpa's triangle, and is comparatively superficial, having *in front* the skin, superficial fascia and fat, inguinal glands, deep fascia, the fascia lata, the crural branch of the genito-crural nerve, and the sheath of the femoral vessels. About the *middle third* it is more deeply seated, and is covered in addition by the sartorius, and lower down by a tendinous aponeurosis, which stretches from the adductor longus and magnus over to the vastus internus. This, which forms part of Hunter's canal, will be examined presently.

The femoral artery in Scarpa's triangle *lies upon* the psoas, the two branches of the crural nerve to the pectineus, the profunda vein, and the pectineus; to its *outer side* it has the crural nerve (separated from it by a few fibres of the ilio-psoas), the profunda artery, and the long saphena nerve; to its *inner* side it has the femoral vein.

Adductor Brevis. — This muscle *arises* from the front surface of the body of the os pubis below the spine, and from

its descending ramus for about an inch (*2.5 cm.*), between the gracilis and the obturator externus; it widens as it descends outwards and backwards, and is *inserted* behind the pectineus into the whole length of the ridge leading from the lesser trochanter to the linea aspera. Behind, it rests upon the posterior division of the obturator vessels and nerve and the adductor magnus. The *action* considered in the *vertical* and *horizontal* positions.

Vertical: external rotation, internal rotation, but only when internal rotation has previously taken place to 25°, the neutral point, adduction and flexion.

Horizontal or *femur flexed to 90°* adduction, external rotation and extension. This flexion limit is 40°. Its nerve is derived from the obturator. By reflecting it from its origin the following muscle is exposed.*

Adductor Magnus.—This muscle arises from the lower part of the descending ramus of the os pubis between the adductor brevis and obturator externus from the margin of the ascending ramus of the ischium, and from the lower and anterior or caudo-ventral part of the tuberosity of the ischium (Fig. 231). Its fibres spread out, and are *inserted* behind the other adductors into the lower part of the linea quadrati into the ridge leading from the great trochanter to the linea aspera, also into the whole length of the linea aspera, and the ridge leading from it to the inner condyle; while those fibres which arise from the tuberosity of the ischium pass vertically downwards or pedad, and are inserted by a rounded tendon into the adductor tubercle on the inner condyle of the femur. Between the muscular fibres of the middle and lower thirds of the insertion of this muscle, the femoral artery passes to the back or dorsum of the thigh. The upper fibres pass transversely outwards to their insertion, while the lower fibres descend nearly vertically. In front of the muscle are the adductor longus and brevis, the vastus internus, the obturator nerve and artery, and the profunda artery; above it are the internal circumflex artery, the obturator externus, and the quadratus femoris; behind it, the biceps, semi-tendinosus and semi-membranosus, the great sciatic nerve, and the gluteus maximus. Its nerve comes from the posterior division of the obturator and the great sci-

* Beneath the adductor brevis, and running parallel with the upper border of the adductor magnus, is seen the obturator externus. But the description of this muscle is deferred till the dissection of the external rotators of the thigh.

atic. Observe that all the adductor muscles are inserted into the femur by flat tendons more or less connected. The *action* considered in the *vertical* and *horizontal* (or *femur flexed at 90°*) positions gives the following: —

Vertical performs external rotation; adduction; extension; external rotation, action of tubercle of insertion; internal rotation, action of tubercle of insertion; adduction, action of tubercle of insertion; extension, action of tubercle of insertion.

Horizontal or femur flexed at 90° performs adduction; external rotation; internal rotation; extension, adduction, action of tubercle of insertion; internal rotation, action of tubercle of insertion; extension, action of tubercle of insertion.

About the junction of the upper two-thirds with the lower third of the thigh the femoral artery passes through an oval opening in the tendon of the adductor magnus, — Hunter's canal.

Psoas Magnus and Iliacus. — These muscles have been fully described in the dissection of the abdomen (p. 481).

Tensor Fasciæ Femoris. — This muscle is situated at the upper and outer part of the thigh (Fig. 232). It *arises* from the anterior part of the external lip of the crest of the ilium, and from the surface below the anterior superior spine. It descends with a slight inclination backwards, and is *inserted* at the junction of the upper with the middle third of the thigh, between two layers of the strong aponeurosis, generally described as part of the fascia lata, which is continued downwards to the head of the tibia, and is called the *ilio-tibial band* (p. 600).* Its chief use is to fix the pelvis steadily on the thigh, and to rotate the thigh inwards; in this last action it co-operates with the anterior fibres of the gluteus medius, with which it is almost inseparably connected. Anyone may convince himself of this by placing his hand on the hip and rotating the thigh inwards. Both these muscles are supplied by the same nerve — the superior gluteal.

To form an adequate idea of the strength, extent, and connections of the aponeurosis on the outer side of the thigh, it should be separated from the vastus externus muscle upon which it lies. There is no difficulty in doing so, for it is united

* The deeper of these two layers runs up to be strongly connected with the tendon of the rectus and the front aspect of the capsule of the hip-joint.

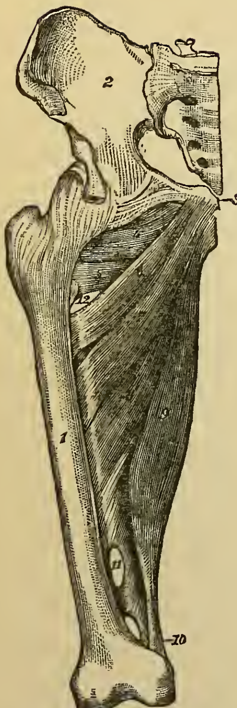


Fig. 231. — Adduction Magnus and Brevis.

1. Femur. 2. Os innominatus. 3. Pubis. 4. Obturator externus. 5. Superior portion of the adductor magnus. 6, 7. Adductor brevis. 8. Middle portion of the adductor magnus, almost entirely covered by the adductor brevis. 9. Inferior portion of the adductor magnus. 10. Tendon attached to the internal condyle. 11. Hunter's canal. 12. Vascular foramen for the circumflex vessels.

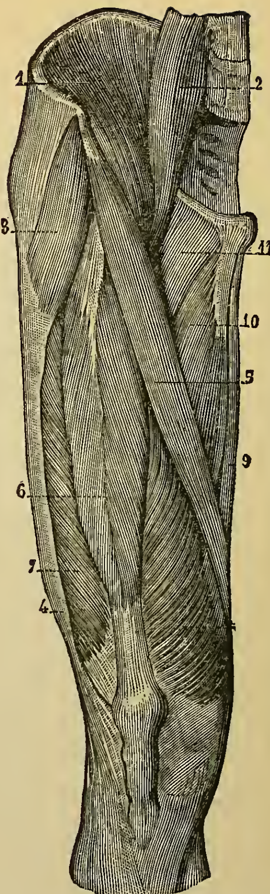


Fig. 232. — Anterior or Ventral Muscle of the Thigh.

1. Iliac bone. 2. Psoas magnus. 3. Tensor fasciæ femoris. 4. Band of fibrous tissue (or sheath) by which the muscle is attached to the forepart of the external tuberosity of the tibia. 5. Sartorius. 6. Rectus femoris. 7. Vastus externus. 8. Vastus internus. 9. Gracilis. 10. Adductor longus. 11. Pectineus.

to the muscle by an abundance of loose connective tissue.* With a little perseverance the aponeurosis can be traced to the

* When this tissue becomes the seat of suppuration, the pus is apt to extend all down the outside of the thigh, not being able to make its way to the surface by reason of the dense fascia.

linea aspera, the head of the tibia, and the fibula, completely protecting the outer side of the knee-joint.

Extensor Muscles or Quadriceps Extensor. — The powerful fleshy muscles occupying the front of the thigh, and situated between the tensor fasciæ on the outer side, and the adductors on the inner, are the extensors of the leg. One of them, the *rectus*, arises from the pelvis; the other arises from the shaft of the thigh-bone by three portions, called, respectively, the *crureus*, the *vastus internus*, and *externus*. All are supplied by the crural nerve.

To see the origins of the rectus femoris, dissect between the origin of the sartorius and the tensor fasciæ; in doing so, avoid injuring the branches of the external circumflex artery.

Rectus Femoris. — This bipenniform muscle *arises* from the pelvis by two strong tendons, which soon unite at an acute angle: one — the straight tendon — is round, and arises from the anterior inferior spine of the ilium; the other — the reflected tendon — is flat, and comes from the rough surface of the ilium, just above the acetabulum (Figs. 230, 7, and 232). The muscle descends along the front aspect of the thigh and is *inserted* into the common extensor tendon, which will be presently examined. The structure of this muscle is remarkable. A tendon runs down the centre, and the muscular fibres are inserted on either side of it, like the vane on the shaft of a feather. Notice also that the surface of the upper part of the rectus is aponeurotic in front and muscular behind, while the reverse is seen at the lower part not far from its insertion. Its nerve comes from the crural.

Triceps Extensor. — This mass of muscle invests like a cloak the greater part of the front and sides of the shaft of the femur; therefore, the whole of it cannot be seen without completely dissecting the thigh. It consists of an outer, middle, and inner portion, called, respectively, the vastus externus, the crureus, and the vastus internus.

The *vastus externus arises* (Fig. 232, 7) by a strong, glistening aponeurosis from the outer side of the base of the great trochanter, from the upper third of the anterior intertrochanteric ridge, from the rough line leading from the greater trochanter to the linea aspera external to the gluteus maximus, from the outer lip of the linea aspera nearly down to the external condyle, and also slightly from the external intermuscular septum. From this origin the fibres pass downwards, forwards, and in-

wards, or pedo-ventro-mesial, and end in a flattened tendon, which is inserted into the outer half of the upper extremity and the external margin of the patella, behind the rectus, to form part of the common extensor tendon, to be presently described, and by a thin aponeurosis is prolonged to the external tuberosity of the tibia and the deep fascia of the leg.

The *vastus internus* and *crureus* should be described as one muscle, for they are inseparably connected (Fig. 232, 8). They arise conjointly by an aponeurosis commencing a short distance below the inner two-thirds of the anterior intertrochanteric ridge, from the upper three-fourths of the front and inner surfaces of the shaft of the femur, from the entire length of the inner lip of the linea aspera, and from the internal intermuscular septum. The outer bundle of muscular fibres — the *crureus* — passes vertically downwards or pedad; the inner — the *vastus internus* — descends forwards and outwards or ventrolaterad, and both are inserted by a common aponeurosis into the inner half of the upper extremity and the internal margin of the patella, and by a thin aponeurosis is prolonged to the internal tuberosity of the tibia and the deep fascia of the leg. The muscular fibres of the vastus internus extend lower than those of the vastus externus.

A few of the deeper fibres of the crureus are inserted into the fold of the synovial membrane of the knee-joint which rises above the patella. These are described as a distinct muscle, under the name of the *sub-crureus*. Their use is to raise the synovial membrane, so that it may not be injured by the play of the patella. Since the triceps is connected to the lower or pedad part of the shaft of the femur only by loose connective tissue, there is nothing to prevent the distension of the synovial membrane, in cases of inflammation, to the extent of several inches above the patella.

Common Extensor Tendon. — The tendon of the rectus, gradually expanding, becomes connected on its under or dorsal surface with the tendon of the crureus, and on either side with that of the vasti, and is firmly fixed into the upper part and sides of the patella. From this bone the common extensor tendon — the *ligamentum patellæ* — descends over the front of the knee-joint, and is *inserted* into the rough part of the tubercle of the tibia. Besides this, the lower fibres of the vasti terminate on a sheet-like tendon, which runs wide of the patella on either side, and is directly inserted into the sides of the head of the

tibia and fibula, so that the knee is completely protected all round. The patella is a large sesamoid bone, interposed to facilitate the play of the tendon over the condyles of the femur; it not only materially protects the joint, but adds to the power of the extensor muscles by increasing the angle at which the tendon is inserted into the tibia.

To facilitate the play of the extensor tendon there are two bursæ. One is placed between the ligamentum patellæ and the smooth part of the tubercle of the tibia, the other between the crureus and the lower or ventro-pedad part of the femur. This last is of considerable size. In early life it is, as a rule, distinct from the synovial membrane of the knee-joint; but after a few years a wide communication frequently exists between them.

Action of the Extensor Muscles.* — The extensor muscles of the thigh are among the most powerful in the body. Great power of extending the knee is one of the essential conditions of the erect attitude. Without it, how could we rise from the sitting position? When erect, how could we walk, run, or spring? The rectus, by taking origin from the pelvis, gains a double advantage: it acts upon two joints simultaneously, bending the thigh while it extends the knee, as when we advance the leg in walking; it also contributes to balance the pelvis on the head of the thigh-bone, and thus prevents the body from falling backwards. We cannot have a better proof of the power of the extensor muscles than when the patella is broken by their sudden contraction — an injury which sometimes happens when a man, slipping backwards, makes a violent effort to recover his balance.

Bursa over the Patella. — The skin over the patella is exceedingly loose, and in the subcutaneous tissue is a bursa of considerable size. Since this bursa is apt to enlarge and inflame in females who are in the habit of kneeling at their work, it is generally called the *housemaid's bursa.* The bursa is not seated precisely over the patella, but extends some way down or pedad on the ligamentum patellæ; indeed, in some cases it is entirely confined to this ligament. This corresponds with the position of the tumor which the bursa occasions when enlarged. Generally speaking, in subjects brought for dissection,

* The rectus, two vasti, crureus, are mentioned by many authors as the quadriceps extensor muscles, because of their united action upon the patella; but as the rectus is the only one of the four that can be easily separated in the dissection it has been described separately. — A. H.

the wall of the bursa is more or less thickened, and its centre intersected by numerous fibrous cords, remnants of the original cellular structure altered by long-continued friction. Again, the wall of the bursa does not always form a complete sac; sometimes there is a wide opening in it: this explains the rapidity with which inflammation, in some cases, extends from the bursa into the surrounding areolar tissue.

Below or dorsad to the bursa is a layer of fascia lata, and under or dorsad to this is a network of arteries. The immediate covering of the bone, or what may be called its periosteum, is a strong expansion derived from the extensor tendon. This is interesting for the following reason: in ordinary fractures of the patella from muscular action the tendinous expansion over it is torn also; the ends of the bone gape widely, and never unite except by ligament. But in fractures from direct mechanical violence, the tendinous expansion, being entire, maintains the fragments in apposition, so that there is commonly a bony union.

The remaining part of the femoral artery can now be examined after the sartorius has been cut through near its centre and both ends reflected. This part of its course corresponds to the middle third of the thigh, and is contained in Hunter's canal.

Femoral Artery in Hunter's Canal.—*In front* of the artery are the skin, superficial and deep fasciæ, the long saphena vein, the sartorius, the long saphenous nerve, and the aponeurotic layer forming the anterior boundary of Hunter's canal: to its *outer side*, are the femoral vein and the vastus internus; to its *inner side*, are the adductor longus, the adductor magnus, and the sartorius; *behind* it, are the adductor longus, the femoral vein, and the adductor magnus. The artery and vein lie close together, and are enclosed in a common sheath.

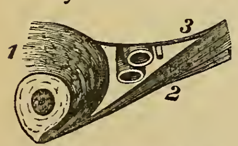


FIG. 233.—SECTION THROUGH HUNTER'S CANAL.
1. Vastus internus. 2. Adductor longus. 3. Aponeurosis thrown across.

Hunter's Canal.—In the middle third of the thigh, the femoral artery is contained in a tendinous canal* beneath the sartorius, called *Hunter's canal.* This canal at its upper part is

* Called Hunter's canal, because it was in this part of its course that John Hunter first tied the femoral artery for aneurism of the popliteal, in St. George's Hospital, A.D. 1785. The particulars of this interesting case are published in the *Trans. for the Improvement of Med. and Chir. Knowledge.*

rather indistinct; but it gradually becomes stronger towards the opening in the tendon of the adductor magnus. Its boundaries are formed by the tendons of the muscles between which the artery runs. On the inner side are the tendons of the adductor longus and magnus; on the outer side is the tendon of the vastus internus; in front, the canal is completed by an aponeurotic expansion thrown obliquely across from the adductors to the vastus internus, as shown in Fig. 233. In a horizontal section the canal appears triangular. The adaptation of this shape to the exigencies of the case is manifest when we reflect that the muscles keep the sides of the triangle always tight, and thereby prevent any compression of the vessels.

Hunter's canal contains not only the femoral artery and vein, but the internal saphenous nerve. The vein lies behind and to the outer side (dorso-laterad); the nerve crosses over the artery from the outer to the inner side.

A ligature can be placed around the artery, in the upper or cephal third of the thigh, with comparative facility; not so easily in the middle third. The artery is tied for an aneurism of the popliteal, just where the sartorius begins to overlap (or is ventrad to) it, for three reasons: (1) it is more accessible; (2) the coats of the artery at this distance are less likely to be diseased; (3) the origin of the profunda is sufficiently far off to admit of the formation of a clot. An incision beginning about three inches (*7.5 cm.*) below or pedad to the crural arch should be made about three inches (*7.5 cm.*) long over the line of the artery. The muscular fascia should be divided on a director to the same extent. Then, by gently drawing aside the inner border of the sartorius, the artery is seen inclosed in its sheath with the vein. An opening should be made into the sheath, which must be carefully separated from the artery to an extent sufficient to allow the passage of the aneurismal needle. The needle should be turned round the artery from within outwards, great care being taken not to injure the vein. The nerves to be avoided are: the long saphenous, which runs along the outer side of the artery, and the internal cutaneous, which crosses obliquely over it.

Having already traced the superficial branches of the femoral artery in the groin, namely, the superficial epigastric, the external pudic, and the superficial circumflexa ilii (p. 596), we pass on now to the profunda.

Profunda Artery and Branches. — The *profunda femoris*, the chief branch of the femoral, is the proper nutrient artery of the muscles of the thigh, and is considered as a division, rather than a branch, of the common femoral artery. It is given off from the outer and back (latero-dorsal) part of the femoral, from one and a half to three inches (*3.8–7.5 cm.*) below or pedad to the crural arch, lying to the outer side of the artery for about two inches (*5 cm.*), and then runs down behind (pedo-dorsally) to the femoral till it reaches the tendon of the adductor longus; here the profunda passes behind or dorsad to the adductor, and, piercing the adductor magnus as a small branch, is finally lost in the hamstring muscles.* In most subjects the profunda, for a short distance after its origin, lies rather on the outer side of the femoral and on a deeper or dorsal plane, on the iliacus: in this situation it might be mistaken for the superficial femoral itself — indeed, such an error has occurred in practice. It soon, however, gets behind or dorsad to the femoral, and lies upon the pectineus, the adductor brevis and magnus; it is separated from the femoral artery, at first, by their corresponding veins; lower down, by the adductor longus.

The branches of the profunda generally arise in the following order: (1) the internal circumflex; (2) the external circumflex; (3) the perforating.

The *internal circumflex* is given off from the inner and back (mesiodorsal) part of the profunda, and then sinks deeply or dorsally into the thigh between the psoas and pectineus. At the lower border of the obturator externus it divides into two branches: one — the *ascending* — supplies the muscles in its neighborhood, namely, the pectineus, psoas, adductors, gracilis, and obturator externus, anastomosing with the obturator artery; the other — the *descending* — passes down to behind or pedo-dorsad to the adductor brevis to supply it and the adductor magnus; the continuation of the artery called the *transverse* will be seen in the dissection of the back or dorsum of the thigh, between the adductor magnus and the quadratus femoris. This latter sometimes gives off a small branch to the hip-joint, which runs through the notch in the acetabulum to the ligamentum teres; it afterwards inosculates with the sciatic, the external circumflex, and superior perforating arteries, forming the *crucial anastomosis*.

The *external circumflex artery* comes off from the outer side of the profunda, runs transversely outwards beneath (dorsad to) the sartorius and rectus between the branches of the crural nerve, and then subdivides into three sets of branches, ascending, transverse, and descending. The *ascending* run up to the outer side of the ilium, beneath or dorsad to the tensor fasciæ and gluteus medius, supply these muscles, and inosculate with the terminal branches of the gluteal and deep

* The point at which the profunda is given off, below or pedad to the crural arch varies very much even in the two limbs of the same body. We have measured it in 19 bodies, or 38 femoral arteries. It varied from half an inch to 3 inches (*13 mm. to 7.5 cm.*). In 22 cases the profundo came off between 1½ and 2 inches (*?.8 5 cm.*); in 9 this distance was exceeded; in 7 this distance was less.

circumflex iliac arteries. The *transverse* pass directly outwards over or latero-ventrad to the crureus, then enter the vastus externus, and get between the muscle and the femur. They inosculate with the sciatic, the internal circumflex, the gluteal, and the perforating arteries. The *descending*, two or more in number, of considerable size, run down or pedad between the rectus and crureus, and supply both these muscles: one branch, larger than the rest, runs in the substance of the vastus externus, along with the nerve to that muscle, and inosculates with the superior articular branches of the popliteal.

The *perforating branches* of the profunda are so named because they pass through the adductors to supply the hamstring muscles. There are generally four. The *first* passes between the pectineus and the adductor brevis, then pierces the adductor magnus, and communicates with the internal and external circumflex, the sciatic, and second perforating arteries. The *second*, the largest, passes through the tendons of the adductor brevis and magnus, divides into an ascending and a descending branch, which anastomose respectively with the first and third perforating arteries. It usually furnishes the nutrient artery of the femur. The *third*, given off below the adductor brevis, passes through the tendon of the adductor magnus.

The *fourth*, or terminal branch, passes through the tendon of the adductor magnus, and supplies the hamstring muscles, and inosculates with the perforating and articular arteries. They not only supply the hamstring muscles — namely, the biceps, semitendinosus, and semimembranosus — but the vastus externus, and even the gluteus maximus. The perforating arteries inosculate with one another, with the internal and external circumflex, and with the sciatic arteries.

Muscular branches, from four to seven in number, are distributed by the superficial femoral to the sartorius and the vastus internus.

The *anastomotica magna* arises from the femoral artery just before it leaves its tendinous canal. It emerges through or pedad from the canal, and runs in front of or ventrad to the tendon of the adductor magnus in company with the long saphenous nerve to the inner or mesial side of the knee. Here it divides into two branches: one, the *superficial*, accompanies the saphenous nerve beneath or dorsad to the sartorius, and is subsequently distributed to the skin; the other, the *deep*, enters the vastus internus, ramifies over or ventrad to the capsules, and communicates with the other articular arteries.*

Arterial Inosculations. — If the common femoral were tied *above* or cephalad to the origin of the profunda, how would the circulation be carried on? The gluteal, the ilio-lumbar, and the circumflex iliac communicate with the ascending branch of the external circumflex; the obturator and sciatic communicate with the internal circumflex (Fig. 234); the arteria comes nervi ischiatici communicates with branches from the lower perforat-

* In its course down the thigh the femoral artery gives off a branch of considerable size for the supply of the vastus internus. We may trace this branch through the substance of the vastus down to the patella, where it joins the network of vessels on the surface of that bone.

ing and popliteal arteries. Again, how is the circulation maintained when the superficial femoral is tied *below* the profunda? The descending branch of the external circumflex and the perforating branches of the profunda communicate with the articular branches of the popliteal and the tibial recurrent.*

Crural Nerve. — The crural nerve is the largest branch of the lumbar plexus (p. 489). It comes from the third and fourth lumbar nerves, also by a small fasciculus from the second. It passes beneath or dorsad to the crural arch, lying in the groove between the iliacus and psoas, about a quarter of an inch to the outer side of the artery, and soon divides into branches, some of which are cutaneous, but the greater number supply the extensor muscles of the thigh. The cutaneous branches, already described (p. 599), and the long saphenous nerve, are given off from the *superficial* part of the trunk; the muscular from the *deep* part.

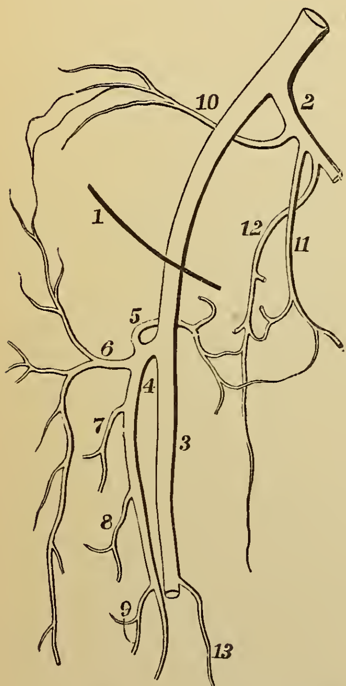


Fig. 234. — Plan of the Inosculations of the Circumflex Arteries.

1. Crural Arch. 2. Internal iliac. 3. Superficial femoral. 4. Profunda. 5. Internal circumflex. 6. External circumflex. 7. First perforating. 8. Second ditto. 9. Third ditto. 10. Gluteal. 11. Obturator. 12. Sciatic. 13. Anastomotica magna.

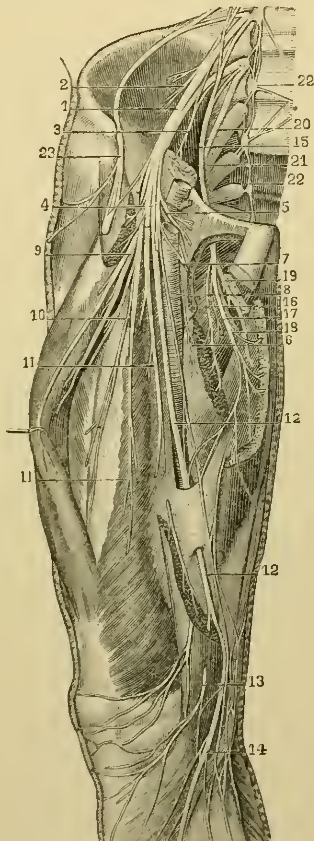
The *long internal saphenous nerve*, the largest of the cutaneous branches, descends close to the outer side of the femoral artery, and enters the tendinous canal with it in the middle third of the thigh. In the canal it crosses over or ventrad to the artery to its inner side. The nerve leaves the artery just before it becomes popliteal, and then runs in company with the anastomotica magna to the inner side of the knee, where it becomes superficial, between the gracilis and the sartorius. In the middle third of the thigh it gives off a small branch which communicates beneath the fascia lata with the internal cutaneous and obturator nerves; and lower down another branch is distributed to the skin over the patella. Its further relations will be seen in the dissection of the leg and foot.

The *muscular branches* are to be traced to the sartorius, rectus, crureus, and subcrureus; the branch to the vastus externus accompanies the descending

* Read the account of the dissection of an aneurismal limb by Sir A. Cooper, *Md. Chir. Trans.*, vol. ii., 1811.

branch of the external circumflex artery, and sends a filament to the knee-joint; that to the vastus internus runs parallel with, but external to, the long saphenous nerve and supplies filaments to the knee-joint. One branch, often two, passes under or dorsad to the femoral artery and vein to enter the anterior or ventral surface of the pectineus.

The *obturator nerve*, also a branch of the lumbar plexus, arising from the second, third, and fourth lumbar nerves (p. 489),



1. The crural.
2. Branch to the iliacus.
3. Filament to the psoas magnus.
4. Three branches of the crural to the skin, divided to show the deeper branches.
5, 6. Muscular filaments of the superficial portion.
7. Internal cutaneous, which pierces the fascia lata.
8. Anastomosing branch of the internal cutaneous.
9. Branch to the rectus femoris.
10. Branch to the vastus externus.
11, 11. Branch to the vastus internus.
12, 12. Internal, or long, saphena nerve.
13. Patellar branch of this nerve.
14. Its vertical branch.
15. Obturator nerve.
16. Its branch to adductor longus.
17. Its branch to the adductor brevis.
18. Its branch to the gracilis.
19. Its branch to the adductor magnus.
20. Lumbo-sacral trunk.
21. Union of this trunk and the first sacral nerve.
22, 22. Lumbar and sacral portion of the sympathetic.
23. External cutaneous nerve.

Fig. 235.—Nerves on the Anterior or Ventral Part of the Thigh.

supplies the adductor muscles. It enters the thigh through the upper or ventral part of the obturator foramen above the corresponding artery, and immediately divides into two branches, of which one passes in front of or ventrad to, the other be-

hind or dorsad to, the adductor brevis. The *anterior* branch subdivides for the supply of the gracilis, the adductor longus, and sometimes the adductor brevis and pectineus; it, moreover, sends a filament to the hip-joint, another to the femoral artery, and a third forms a plexiform communication at the lower border of the adductor longus with the internal cutaneous and long saphenous nerves. The *posterior* branch supplies the obturator externus, the adductor brevis and magnus. In some bodies you can trace a filament of this nerve through the notch of the acetabulum into the hip-joint, and another, which runs near the popliteal artery, into the back or dorsal part of the knee-joint. We have frequently seen cutaneous branches from the obturator on the inner side of the thigh. This is interesting practically, since it helps to explain the pain often felt on the inner side of the knee in disease of the hip-joint.

The *accessory obturator nerve*, when present, comes either from the obturator nerve or from the third and fourth lumbar nerves. Descending, it runs between the horizontal ramus of the os pubis and the pectineus, and supplies a branch to this muscle, also a filament of communication to the anterior branch of the obturator, and a third branch to the hip-joint.

The *obturator artery*, after passing through or ventrally the foramen, divides into two branches, an *internal* and an *external*, which form a circle round the obturator membrane. These supply the external obturator and adductors of the thigh, and inosculate with the internal circumflex artery (p. 624). The latter branch sometimes gives off the small artery to the ligamentum teres of the hip-joint.

DISSECTION OF THE FRONT OF THE LEG.

Surface Marking.—About an inch (*2.5 cm.*) below or pedad to the patella is the prominent tubercle of the tibia, to which the ligamentum patellæ is attached; on each side of this is a depression, filled with more or less fat. About the same distance below the outer tuberosity of the tibia is the head of the fibula, situated far back, and to it can be traced the tense tendon of the biceps. The crest of the tibia is easily felt in front, commencing above at the outer tuberosity, and passing down nearly vertically, gradually inclining to the inner side so that it is continuous below the front of the internal malleolus.

Internal to the crest is the subcutaneous internal surface of the tibia, and externally is the interval between the tibia and the fibula, which is filled up by the extensor muscles. The lower fourth of the fibula is subcutaneous, ending in a well-marked prominence, the external malleolus, which, it should be observed, descends lower, than the internal malleolus. The student should notice well the tendons which surround the ankle-joint, which are easily recognizable under the skin; thus, behind, the tendo Achillis protrudes prominently, having a deep depression on each side; on the outer side, the tendons of the peronei longus and brevis are felt, the latter being the anterior. Running round the inner malleolus we can only feel the tibialis posticus close to the tibia, and next to it the flexor longus digitorum; in front of the ankle, but ensheathed by the anterior annular ligament, can be felt, from within outwards, the strong tendon of the tibialis anticus, the extensor proprius hallucis, and the long extensor of the toes with the peroneus tertius.

The foot should be turned inwards, and fixed in this position. An incision must be made pedad from the knee ventrally to the leg, ankle, foot, and great toe; a second, at right angles to the first, on either side of the ankle; a third, across the bases of the toes. Reflect the skin from the front and sides of the leg and foot.

Cutaneous Veins and Nerves. — Having traced the internal saphena vein (p. 598) to the inner side of the knee, follow it down the inner side of the leg, in front of the inner malleolus * to the dorsum of the foot. On the dorsum of the foot notice that the principal veins form an arch, with the convexity forwards, as on the back or dorsum of the hand. This arch receives the veins from the toes. From the inner side of the arch the *internal* long *saphena* originates; from the outer side, the external saphena. The latter vein commences on the outer side of the arch on the dorsum, runs behind the external malleolus, along the outer border of the tendo Achillis up the back or dorsum of the calf of the leg, between the two heads of the gastrocnemius, and finally pierces the deep fascia at the lower or pedad part of the popliteal space, to join the popliteal vein. The external saphenous nerve accompanies this vein, as the long saphenous nerve does the internal saphena vein.

* The French commonly bleed from the internal saphena vein as it crosses over the inner malleolus, this being a convenient and safe place for venesection.

Long Saphenous Nerve. — The skin on the inner side of the leg is supplied by the long internal saphenous nerve (p. 626). It becomes subcutaneous on the inner or mesial side of the knee, between the gracilis and sartorius (Fig. 235, 12). Here it meets the saphena vein, and accompanies it down the leg, distributing its branches on either side, till it is finally lost on the inner side of the foot and the great toe. The largest branch curves round the inner side of the knee, just below the patella, to supply the skin in this situation. It pierces the sartorius close to the knee, and forms, with branches from the internal, middle, and external, cutaneous nerves, the *plexus patellæ.*

The *internal cutaneous nerve* supplies the skin of the upper and inner aspect of the leg, and joins the internal saphenous nerve.

The skin on the front and outer parts of the upper half of the leg is supplied by *cutaneous branches* from the *external popliteal* or *peroneal* nerve; the skin of the lower half by its *external cutaneous branch,* as follows: —

External Cutaneous Branch of the Peroneal Nerve. — This branch of the peroneal nerve comes through (Fig. 240, 2) the fascia about the lower third of the outer side of the leg, and, descending over the front of the ankle, divides into two. Trace them, and you will find that the *inner,* and smaller, supplies the inner side of the great toe, and the contiguous sides of the second and third toes; towards its termination it communicates with the long saphenous and anterior tibial nerves. The *outer* distributes branches to the outer side of the third toe, both sides of the fourth, and the inner side of the fifth toe, and joins the short or external saphenous nerve.

The outside of the little toe is supplied by the external saphenous nerve, which runs behind to the outer malleolus with the corresponding vein.

The contiguous sides of the great and second toes are supplied by the termination of the anterior tibial nerve.*

Muscular Fascia and Annular Ligaments. — This is remarkably thick and strong. Besides its general purpose of forming sheaths for the muscles, and straps for the tendons, it gives origin, as in the forearm, to muscular fibres, so that it

* Such is the most common distribution of the nerves to the upper or dorsal surface of the toes. But deviations from this arrangement are frequent.

cannot be removed near the knee without leaving the muscles ragged. The fascia, continuous above with the fascia lata, is attached to the head of the tibia and the fibula; it is connected on the inner side with the expanded tendons of the sartorius, gracilis, and semi-tendinosus; on the outer side with that of the biceps; consequently, when these muscles act, it is rendered tense. Following it down the leg, you find that it is attached to the edge of the tibia, and that it becomes stronger as it approaches the ankle, to form the ligaments which confine the tendons in this situation. Of these ligaments, called *annular*, there are three, as follows: —

a. The *anterior annular ligament* extends obliquely across the front of the ankle-joint, and confines the extensor tendons of the ankle and toes. It consists of two converging straps — one oblique, the other horizontal, which join and are continued on as a common band, like the letter $\prec$ placed transversely; the upper or oblique binds down the tendons in front of the lower end of the tibia; the lower or oblique the tendons which lie over the tarsus. The common band is attached to the external malleolus, cuboid, and os calcis; it is continued horizontally inwards for a short distance, and in front of the ankle splits into two fasciculi; the upper or oblique ascends to be attached to the tibia; the lower or horizontal passes inwards to be attached to the internal malleolus, the scaphoid, and the internal cuneiform. Beneath the upper fasciculus, enclosed in two synovial sheaths, run the tibialis anticus on the inner side, and the extensor longus digitorum and peroneus tertius on the outer side; the extensor proprius hallucis and the anterior tibial vessels lying behind or dorsad to the ligament, but not having any synovial sheath. Beneath the lower fasciculus are three synovial sheaths — an inner one for the tibialis anticus, a middle one for the extensor proprius hallucis, and an outer one for the extensor longus digitorum and peroneus tertius. It is the strain of this ligament which occasions the pain in sprains of the ankle.

b. The *external annular ligament* extends from the outer malleolus to the os calcis, and confines the tendons of the peronei muscles, which are enclosed in a common synovial sheath.

c. The *internal annular ligament* is a strong fasciculus of ill-defined fibrous tissue which extends from the inner mallėolus to the os calcis, where it becomes continuous with the plantar fascia and the tendinous origin of the abductor hallucis. It confines the flexor tendons of the foot and toes, and as these pass

round the inner ankle it forms three compartments, each lined with a separate synovial sheath — one each for the tibialis posticus, the flexor longus digitorum, and the flexor longus hallucis.

Remove the fascia, leaving enough of the annular ligaments to retain the tendons in their places.

Muscles on the Front of the Leg. — The muscles on the front of the leg are: (1) the tibialis anticus; (2) the extensor longus digitorum and peroneus tertius; (3) the extensor proprius hallucis.

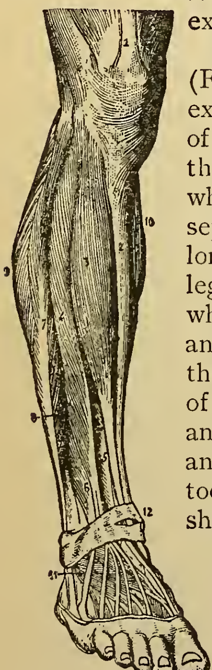


Fig. 236. — Anterior Muscles of the Leg.

1. Tendon of the rectus femoris. 2. Tibia. 3. Tibialis anticus. 4. Extensor longus digitorum. 5. Extensor proprius hallucis. 6. Peroneus tertius. 7. Peroneus longus. 8. Peroneus brevis. 9. External head of the gastrocnemius. 10. Internal head of the gastrocnemius. 11. Extensor brevis digitorum. 12. Annular ligament (anterior or ventral).

Tibialis Anticus. — The tibialis anticus (Fig. 236, 3) *arises* by fleshy fibres from the external tuberosity and the upper two-thirds of the outer side of the shaft of the tibia, from the interosseous membrane, from the fascia which covers it, and from the intermuscular septum which separates it from the extensor longus digitorum. About the lower third of the leg the fibres terminate on a strong flat tendon, which descends obliquely over the front of the ankle, through the innermost compartment of the anterior annular ligament, to the inner side of the foot; here it becomes a little broader, and is *inserted* into the internal cuneiform bone and the base of the metatarsal bone of the great toe. The synovial membrane, which lines the sheath of the tendon beneath the anterior annular ligament, accompanies it to within an inch (*2.5 cm.*) of its insertion; consequently, it is opened when the tendon is divided for club-foot. The action of this muscle is to draw the foot upwards and inwards (ventromesially).* When the foot is the fixed point, it assists in balancing the body at the ankle. Its nerve comes from the anterior tibial.

Extensor Longus Digitorum. — This muscle lies along the fibular side of the preceding (Fig. 236, 4). It *arises* from the external tuberosity of the tibia, from the upper three-fourths of the anterior

* It is generally necessary to divide this tendon in the distortion of the foot inwards called talipes varus.

surface of the shaft of the fibula, from the interosseous membrane, from the fascia of the leg and the intermuscular septa. Its fibres terminate in a penniform manner upon a long tendon situated on the inner side of the muscle; this tendon descends in front of the ankle, and divides into four slips, which pass to the four outer toes. They diverge from each other, and are *inserted* into the toes thus: On the base of the first phalanx each tendon (except that of the little toe) is joined on its outer side by the corresponding tendon of the extensor brevis (11), and a little further on by a fibrous expansion from the interosseous and lumbrical muscles. The united tendons then expand, cover the dorsal surface of the first phalanx, and at the articulation between this and the second phalanx split into three fasciculi; the middle one is inserted into the base of the second phalanx; the two lateral ones running on and reuniting are inserted into the base of the third phalanx. Its nerve comes from the anterior tibial.

Immediately below the ankle the anterior annular ligament forms a pulley through which the tendon of this muscle plays. It is like a sling, of which the two ends are attached to the os calcis, while the loop serves to confine the tendon. The play of the tendon is facilitated by a synovial membrane, which is prolonged for a short distance along each of its four divisions. Besides its chief action, this muscle extends the ankle-joint.*

Peroneus Tertius. — This is a portion of the preceding (Fig. 236, 6). Its fibres *arise* from the lower fourth of the anterior surface of the shaft of the fibula, the interosseous membrane, and the intermuscular septum between it and the peroneus brevis (8), and terminate on their tendon like barbs on a quill. The tendon passes through the same synovial pulley with the long extensor of the toes, and expanding considerably is *inserted* into the tarsal end of the metatarsal bone of the little toe. It is not always present. It is supplied by a branch of the anterior tibial nerve. This muscle extends the foot and draws the outer border of the foot upwards.

The peroneus tertius and the tibialis anticus are important muscles in progression. They raise the toes and foot from the ground. Those who have lost the use of these muscles are

* There is often a large bursa between the tendon of the extensor longus digitorum and the outer surface of the astragalus. This bursa sometimes communicates with the joint of the head of the astragalus.

obliged to drag the foot along the ground, or to swing the entire limb outwards in walking.

Extensor Proprius Hallucis. — This muscle (Fig. 236, 5) lies partly concealed between the tibialis anticus and the extensor longus digitorum. It *arises* from rather more than the middle third of the anterior surface of the fibula, and from the interosseous membrane. The fibres terminate in a penniform manner on the tendon, which runs over the ankle, between the tendons of the tibialis anticus and the extensor longus digitorum, along the top of the foot to the great toe, where it is *inserted* into the base of the last phalanx. It has a special pulley beneath the horizontal portion of the anterior annular ligament lined by a synovial membrane, which accompanies it as far as the metatarsal bone of the great toe. It is supplied by the anterior tibial, a branch of the peroneal nerve.

Now examine the course, relations, and branches of the anterior tibial artery. Since it lies deeply between the muscles, it is necessary to separate them from each other; this is easily done by proceeding from the ankle towards the knee.

Course and Relations of the Anterior Tibial Artery. — The *anterior tibial artery* is one of the two branches into which the popliteal divides at the lower border of the popliteus. It comes at first horizontally forward about $1\frac{1}{4}$ inch (*3.1cm.*) below the head of the fibula, between the two heads of the tibialis posticus, above the interosseous membrane, and then descends, lying in rather more than the first half of its course upon or ventrad to the interosseous membrane, afterwards along the front of or ventrad to the tibia. It runs beneath to the anterior annular ligament over the front of the ankle, where it takes the name of the dorsal artery of the foot. Thus, a line drawn from the head of the fibula to the interval between the first and second metatarsal bones would nearly indicate its course. In the upper third of the leg it lies deeply between the tibialis anticus and the extensor longus digitorum; in the lower two-thirds, between the tibialis anticus and the extensor proprius hallucis. In *front of the ankle* the artery is crossed by the extensor proprius hallucis, and lies between the tendon of this muscle and the inner tendon of the extensor longus digitorum.

The artery is accompanied by the anterior tibial nerve (a branch of the peroneal), which runs for some distance upon its fibular side, then in front of it, and lower down is again situated

on its outer side. It is accompanied by two veins, one on each side, which communicate at intervals by cross branches.

The branches of the anterior tibial are as follows: —

a. The *recurrent tibial* branch ascends close by the outer side of the head of the tibia, though the tibialis anticus, to the front of the knee-joint, where it inosculates with the other articular arteries derived from the popliteal, and with the anastomotic magna.

b. Muscular branches, in its course down the leg, and others which pierce the interosseous membrane, and communicate posteriorly with branches of the posterior tibial and peroneal arteries.

c. The *malleolar* branches, *external* and *internal* ramify over the ankle: the *external*, descending beneath the tendon of the extensor longus digitorum and peroneus tertius, ramifies on the external malleolus, inosculating with the anterior peroneal and the tarsal arteries; the *internal* passes beneath the extensor proprius hallucis and the tibialis anticus, and anastomoses with the posterior tibial, with its internal calcanean branch, and with the internal plantar artery. They supply the joint, the articular ends of the bones, and the sheaths of the tendons around them.

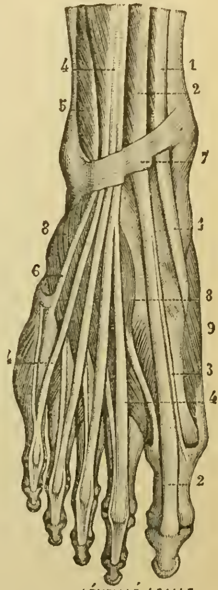


FIG. 237.—EXTENSOR TENDONS OF THE TOES.

1, 1. Tendon of the tibialis anticus. 2, 2. Tendon of the extensor proprius hallucis. 3. Very slender division of this tendon attached to the proximal phalanx of the great toe. 4, 4. Extensor longus digitorum. 5. Peroneus tertius. 6. Its tendon attached to the 5th metatarsal. 7. Annular ligament. 8, 8. Commencement of the tendon and of the extensor brevis digitorum. 9. Adductor hallucis.

Extensor Brevis Digitorum. — This muscle is situated on the dorsum of the foot, beneath the long extensor tendons of the toes. It *arises* from the outer part of the os calcis, from the external calcaneo-astragaloid ligament, and from the anterior annular ligament. The fibres run obliquely over the foot, and terminate in four tendons, which pass forwards to the four inner toes. The inner one, and the largest, is *inserted* by an expanded tendon into the base of the proximal phalanx of the great toe; the others *join* the fibular side of the long extensor tendons to be inserted with them into the central and ungual phalanges. The tendon to the great toe crosses over the dorsal artery of the foot. The *action* is to extend the four toes nearest the mesial line. From the obliquity of the muscle from origin to insertion the outer phalanges will be extended and abducted if the muscle could

act alone, but the long extensor counteracts and hence performs only extension. The tendon to the proximal phalanx of the great toe assists in adduction of this digit. It is supplied by a branch of the anterior tibial nerve.

Dorsal Artery of the Foot. — This artery, the continuation of the anterior tibial, runs over the instep to the rear of the interval between the first and second metatarsal bones, where it divides into two branches — one, the dorsalis hallucis, runs along the dorsal aspect and the first interosseous space; the other, the communicating, sinks into the sole and joins the deep plantar arch. On the dorsum of the foot the artery *lies upon* the astragalus, the scaphoid, and the internal cuneiform bones, separated, however, from them by their dorsal ligaments; *in front* the artery has the skin, superficial and deep fasciæ, the venous arch across the dorsum, and the tendon of the short extensor of the great toe; on its *outer side*, it has the extensor longus digitorum, and the anterior tibial nerve on its *inner side*, the extensor proprius hallucis. The dorsal artery gives off the following branches: —

a. The *tarsal* branch arises near the scaphoid bone, passes outwards in an arched direction beneath or entad to the extensor brevis digitorum towards the outside of the foot, supplies the bones and joints of the tarsus, and inosculates with the external malleolar, the peroneal, the metatarsal, and the external plantar arteries.

b. The *metatarsal* branch generally runs towards the outside of the foot, in front of and parallel with the tarsal artery, beneath the short extensor tendons, near the bases of the metatarsal bones, and gives off the three outer *dorsal interosseous arteries.* These pass forwards over the corresponding interosseous muscles, supply them, and then subdivide to supply the contiguous sides of the upper surfaces of the toes. The outer interosseous branch, in addition to giving off a branch to the fourth interosseous space, gives off a small branch to the outer side of the little toe. They receive, at the rear of each interosseous space, the posterior perforating branches of the plantar arch, and at the front of each interosseous space they receive the anterior perforating branches from the plantar digital arteries.

c. The *dorsalis hallucis* is, strictly speaking, the artery of the first interosseous space. It is the continuation of the dorsal artery of the foot, after it has given off the communicating branch to the sole, and runs forwards to supply *digital branches* to the sides of the great toe and the inner side of the second toe.

Peronei Muscles. — These muscles are situated on the outer side of the fibula, and are named, respectively, peroneus longus and brevis.

Peroneus Longus. — This *arises* from the head and the outer surface of the fibula along its upper two-thirds, from the deep fascia which covers it, and the intermuscular septa. The fibres terminate in a penniform manner in a tendon, which

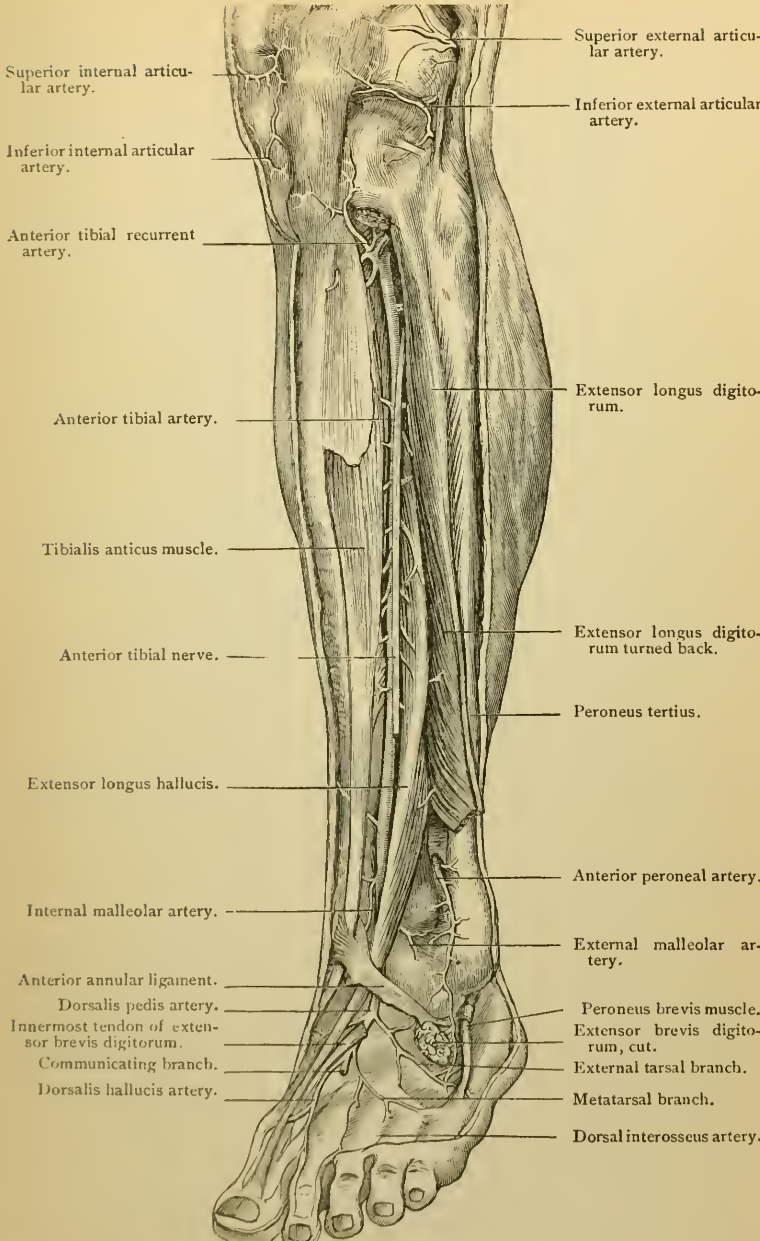


Fig. 238.—The Anterior Tibial Artery, Dorsal Artery of the Foot, and Anterior Peroneal Artery, and their Branches, Left Side. (Morris.)

runs with the peroneus brevis, in a groove behind or dorsad to the external malleolus, then along the outer side of the os calcis, and, lastly, through a groove on the under or plantar surface of the os cuboides deep into the sole. It crosses the sole obliquely forwards and inwards, or ventro-mesially, and is *inserted* into the tarsal end of the metatarsal bone of the great toe, and usually into the internal cuneiform bone. In its course through these several bony grooves the tendon is confined by a fibrous sheath, lined by a synovial membrane. In removing the metatarsal bone of the great toe, if possible, leave the attachment of this tendon, which is usually inserted by means of a sesamoid bone. Its nerve comes from the peroneal.

Peroneus Brevis. — This muscle lies beneath the preceding. It *arises* from the lower two-thirds of the outer surface of the fibula, internal to the preceding muscle, and from the intermuscular septa. It terminates in a tendon which runs behind the external malleolus, through the same sheath with the peroneus longus, then proceeds along the outside of the foot, and is *inserted* into the dorsal surface of the tarsal end of the metatarsal bone of the little toe. Laterally on the os calcis there is a ridge which separates the tendons of the peronei. Each has a distinct sheath. The short tendon runs above the long one below the ridge. Its nerve is from the musculo-cutaneous branch of the peroneal nerve.

The *action* of the peronei is to raise the outer side of the foot.* This movement regulates the bearing of the foot in progression, so as to throw the principal part of the weight on the ball of the great toe. Its action is well exemplified in skating. Again, supposing the fixed point to be at the foot, they tend to prevent the body from falling on the opposite side, as when we balance ourselves on one leg.

Peroneal or External Popliteal Nerve. — Near the inner side of the tendon of the biceps flexor of the leg is a large nerve, the *external popliteal* or *peroneal*, a branch of the great sciatic. By reflecting the upper part of the peroneus longus, you will find that this nerve runs round the outer side of the fibula immediately below its head, and, piercing the origin of the peroneus longus, divides into two main branches — the anterior tibial and the musculo-cutaneous nerves. It gives off several branches as follows: 1. *Articular branches*, two in

* In distortion of the foot outwards, called talipes valgus, it is generally necessary to divide the tendons of the peronei.

Fig. 239.—Muscles of the Fibular Region.

1. Tibialis anticus. 2. Extensor longus digitorum. 3. Tendon of the extensor proprius hallucis. 4. Peroneus tertius. 5. Peroneus brevis. 6. Peroneus longus. 7. Soleus. 8. External head of the gastrocnemius. 9. Head of the fibula. 10. Tendon of the biceps. 11. Semi-membranosus. 12. Tendon of the rectus femoris. 13. Tendo Achillis. 14. External malleolus. 15. Annular ligament. 16. Insertion of the peroneus tertius. 17. Insertion of the peroneus brevis. 18. Extensor brevis digitorum 19. Abductor minimi digiti. 20. Patella.

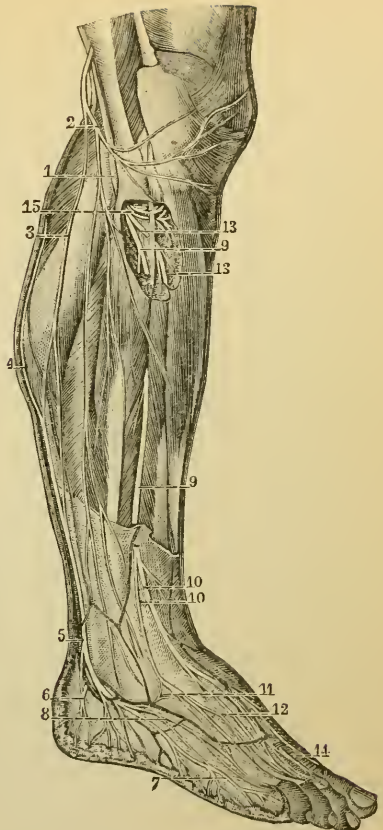


Fig. 240.—Peroneal, External, or Lateral Popliteal Nerve.

1. External popliteal or peroneal. 2. Cutaneous branch. 3. Communicans peronei. 4. External saphena. 5. Trunk formed by the union of the external saphena with the accessory of the cutaneous 6. Calcanean branch. 7. Terminal branch going to 5th toe. 8. Terminal branch to 4th and 5th toes. 9, 9. Musculo-cutaneous. 10, 10. Its terminal branches. 11. Anastomosis of the musculo-cutaneous with the external saphena. 12. Anastomosis of the internal and external or lateral branches of the musculo-cutaneous. 13. Anterior tibial. 14. Terminal branch of anterior tibial, supplying deeper structure great and index toes and anastomosing with the musculo-cutaneous.

number to the knee-joint, which pass in with the external articular arteries, and a third which accompanies the tibial recurrent artery. 2. *Cutaneous branches,* two or more, supply

the skin on the back and outer aspect of the leg, and one, the *communicans peronei*, which joins the external saphenous to supply the dorsal aspect of the outer side of the little toe: this will be seen later on in the dissection of the back of the leg. 3. The *anterior tibial*, which accompanies the corresponding artery and supplies the muscles between which it runs — namely, the tibialis anticus, extensor longus digitorum, extensor proprius hallucis, and peroneus tertius; also the extensor brevis digitorum. 4. The *musculo-cutaneous* (p. 630), which comes through ventrally the fascia between the peroneus longus and the extensor longus digitorum. 5. *Branches*, which supply the peronei longus, and brevis, muscles.

If, then, the peroneal nerve were divided in the popliteal space, the result would be paralysis of the tibialis anticus, the extensors of the toes, long and short, and all the peronei.

DISSECTION OF THE GLUTEAL REGION.

The body having been placed on its face, the pelvis is to be raised to such a height by blocks beneath it, that the lower extremities hang down over the end of the table. Then rotate the thighs inwards as much as possible, and cross them.

Surface Marking. — The bony prominences are very marked and prominent; they are, on the outer side, the great trochanter, and, on the inner, the posterior superior spine of the ilium, the spines of the sacral vertebræ, which are continued on to the coccyx. Between the latter bone and the great trochanter is the rounded tuberosity of the ischium, which in the erect position is covered by the gluteus maximus, but is uncovered by it when the femur is flexed. Notice a transverse curved fold of the skin extending from the coccyx to the base of the great trochanter, which does not, as it might be thought, correspond with the lower border of the gluteus maximus, which is caudad or much lower. The fact is important to bear in mind in operations for stretching the great sciatic nerve, for the relief of sciatica or other affections of the nerve or its branches. The buttock is convex towards its inner part, and in health presents on its outer side a hollow behind the great trochanter, which usually becomes lost in hip-joint disease. The back or dorsum of the thigh is convex, and towards its lower or genual part it presents a flattening, corresponding to the lozenge-shaped

hollow of the popliteal space, so that the tendons and muscles forming its boundaries can be easily distinguished.

The incision through the skin should commence at the coccyx, and be continued in a semicircular direction along the crest of the ilium. Another incision should be made from the coccyx downwards and outwards or pedo-laterally for about six inches (*15 cm.*) below or genuad the great trochanter. In reflecting the skin, notice the thick cushion which the subcutaneous adipose tissue forms over the tuberosity of the ischium, and the peculiar manner in which the fat is enclosed in meshes formed by dense connective tissue. A large bursa is often formed between this cushion and the bone.

Cutaneous Nerves. — These are derived from the following sources: — *Branches* from the posterior divisions of the *first* and *second lumbar nerves* descend over the crest of the ilium, near the origin of the erector spinæ, to supply the skin over the gluteus maximus as far as the great trochanter (Fig. 138, p. 369).

Branches from the posterior branches of the *three upper sacral nerves* pass downwards and outwards or caudo-laterally to supply for a short distance the integument over the sacrum and coccyx.

The *lateral branch* of the *twelfth thoracic nerve* descends vertically over the crest of the ilium, near to its anterior part, and supplies the ventral integument of the gluteal region.

The *iliac branch* of the *ilio-hypogastric nerve* passes over or cephalad to the crest of the ilium, between the posterior or dorsal branches of the lumbar nerves and the preceding nerve, and supplies for a short distance the skin of the buttock.

The *external cutaneous nerve* distributes cutaneous branches to the lower and outer part of the buttock over the great trochanter.

Cutaneous branches from the *lesser sciatic nerve* proceed upwards from beneath to the lower border of the gluteus maximus to supply the skin over the lower part of this muscle.

Gluteal Muscles. — Three powerful muscles are situated in the region of the buttock, one above the other, named, according to their size, the gluteus maximus, medius, and minimus. The fascia covering the gluteus maximus is comparatively thin, dorsally, where it is attached to the sacrum, coccyx, and ilium; but ventrally it is very dense and glistening, and gives origin to

the fibres of the gluteus medius, and lower down becomes continuous with the fascia lata.*

Gluteus Maximus. — This is the largest muscle of the body, and is covered by a fascia, which sends prolongations inwards or entally deeply between the muscular bundles (Fig. 241). Its great size is characteristic of man, in reference to his erect position. Its texture is thick and coarse. It *arises* from the posterior fifth of the crest of the ilium, and from the rough surface below it, from the dorsal surfaces of the caudal segments of the sacrum, the coccyx, and the great sacro-sciatic ligament. The fibres descend obliquely dorso-laterally, and are *inserted* thus: The anterior two-thirds terminate on a strong broad aponeurosis which plays over the great trochanter, and joins the fascia lata of the thigh (Fig. 223, p. 600); the remaining third is inserted into the femur, along the gluteal ridge leading from the linea aspera to the base of the great trochanter. The *action* considered in the *vertical* or hanging position is that of *external rotation* by that part posterior to a line projected through the axis of the femur, *internal rotation* by that part anterior to this line, abduction by that part posterior to the femural axial line; *adduction* by that part anterior to the femural axial line; extension by the whole muscle. The *action* with the *femur horizontal* at 90° gives abduction, adduction, internal rotation, external rotation, flexion and extension by part of the muscle acting to perform each function.†

This muscle *extends* the thigh-bone upon the pelvis, and is therefore one of those most concerned in raising the body from the sitting to the erect position, and in maintaining it erect. It propels the body in walking, running, or leaping, and rotates the thigh outwards. It is supplied with blood by the gluteal and sciatic arteries; with nerves from the lesser sciatic, and the sacral plexus.

What is seen beneath the Gluteus Maximus. — The gluteus maximus should be reflected from its origin. The best way is to begin at the front or ventral border, which overlaps

* As the fascia leaves the lower border of the gluteus maximus it divides, one portion going, as stated, to the fascia lata and the other being firmly attached to the tuberosity of the ischium and to the tendon of the muscle at its lower margin; the fascia then, becoming more delicate, proceeds upwards, forming the internal covering of the muscle. As the sciatic nerve emerges it hugs close to the tuberosity; the fascia, therefore, makes a tentorium posteriorly which is always tensed when the gluteus maximus is in action. — A. H.

† *Phila. Med. Jour.*, Prize Contest, 1. 1. 99. Dr. Eb. W. Thomas.

the gluteus medius. The dissection is difficult, and he who undertakes it for the first time is almost sure to injure the subjacent parts. The numerous vessels which enter its under surface must be divided before the muscle can be reflected. This having been accomplished, the following objects will be exposed: —

The muscle covering the ilium is the gluteus medius. At the posterior border of this are the several objects which emerge from the pelvis through the great sciatic notch — namely, the pyriformis muscle, above is the trunk of the gluteal vessels and nerve, and below are the greater and lesser sciatic nerves, the arteria comes nervi ischiatici, the long pudendal nerve, the sciatic vessels, the pudic vessels and nerve, the nerve to the obturator internus and the coccygeus. Coming through the lesser sciatic notch, is the tendon of the obturator internus and attached to it are the gemelli muscles, one cephalad, the other caudad to it. Extending from the tuber ischii transversely outwards to the great trochanter is the quadratus femoris, and, below this, is seen the upper part of the adductor magnus. The origins of the semi-membranosus, biceps, semi-tendinosus, and of the adductor magnus, from the tuber ischii, are also seen; as well as the great sacro-sciatic ligament, which passes upwards to the sacrum, and is pierced by the coccygeal branch of the sciatic artery. The great trochanter is exposed, together with a small portion of the vastus externus; and where the tendon of the gluteus maximus plays over the trochanter major, there is a large bursa, simple or multilocular. Lastly, the side of the sacrum, the coccyx, part of the crest of the ilium, the tuberosity of the ischium, are brought into view.

Gluteus Medius. — This muscle, covered behind by the gluteus maximus, and in front by the fascia lata, *arises* from the surface of the ilium, between the crest and the upper curved line; also from the strong fascia which covers it towards the front. The fibres converge to a tendon, which is *inserted* into the oblique line on the upper and outer surface of the great trochanter: some of the anterior fibres — in immediate connection with the tensor fasciæ — terminate on the aponeurosis of the thigh. Between its insertion and the bone is a bursa. The *action* with femur vertical performs *internal rotation* and *external* rotation by part of the muscle. Abduction and extension by the whole muscle. The action with the femur horizontal at 90° performs abduction, adduction, flexion and ex-

tension by part of the muscle, but internal rotation by the entire muscle.*

Reflect the gluteus medius to see the third gluteal muscle. The line of separation between them is marked by a large branch of the gluteal artery.

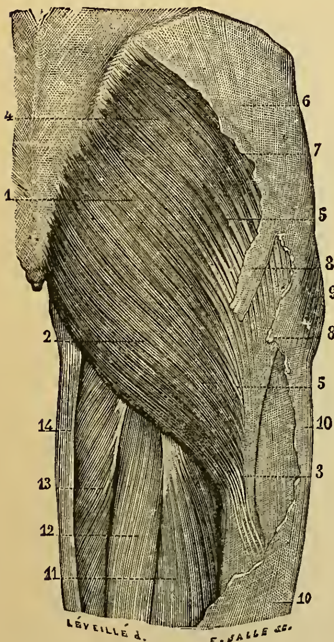


FIG. 241.—GLUTEUS MAXIMUS MUSCLE.

1. Gluteus maximus. 2. Its inferior part. 3. Serrated tendon attached to the gluteal ridge leading to the linea aspera. 4. Superior part of the muscle. 5, 5. Commencement of the tendon of insertion. 6. Superior part of the fascia lata. 7. Dividing of this fascia at the superior border of the gluteus maximus. 8. Portion of the fascia which is adherent to the tendon. 9. The tensor fascia femoris. 10, 10. Fasica lata. 11. Biceps. 12. Semi-tendinosus. 13. Semi-membranosus. 14. Gracilis.

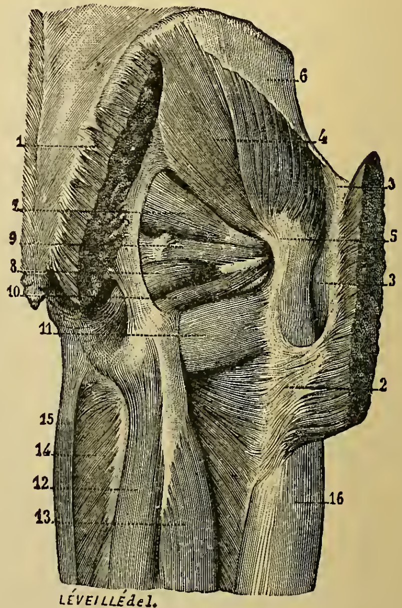


FIG. 242.—MUSCLE BENEATH THE GLUTEUS MAXIMUS.

1. Origin of gluteus maximus divided. 2. Its insertion into the oblique line. 3, 3. Its insertion into the fascia lata. 4. Gluteus medius. 5. Its insertion. 6. Fascia lata, showing continuity with insertion of the gluteus maximus. 7. Pyriformis. 8. Obturator internus. 9. Gemellus superior or cephalad. 10. Gemellus inferior. 11. Quadratus femoris. 12. Semi-membranosus. 13. Biceps. 14. Adductor magnus. 15. Gracilis. 16. Vastus externus.

Gluteus Minimus.—This muscle *arises* from the surface of the ilium below the upper and lower curved lines, and as far dorsally as the margin of the great sacro-sciatic notch. Its fibres pass over the capsule of the hip-joint, and converge to

* *Phil. Med. Journal*, Prize Contest, 1, 1, 99. Dr. Eb. W. Thomas.

a tendon which is *inserted* into a depression on the front part of the great trochanter, a bursa being interposed. This muscle and the preceding are supplied by the superior gluteal nerve, a branch of the lumbo-sacral cord. The *action* when *vertical* is that of internal rotation by part of the muscle; external rotation by part of the muscle; abduction by the whole muscle; extension by the whole muscle. With the femur *horizontally* flexed at 90°, the action will be abduction by part of the muscle; adduction by part of the muscle; internal rotation by the whole muscle; and flexion by the whole muscle.* The chief action of this and the preceding muscle is to assist in balancing the pelvis steadily on the thigh, as when we are standing on one leg; with the fixed point at the ilium, they are abductors of the thigh. The anterior fibres of the gluteus medius co-operate with the gluteus minimus and the tensor fasciæ in *rotating the thigh inwards.*

Gluteal Vessels and Nerves. — The *gluteal artery* is the largest branch of the internal iliac (p. 525). Emerging from the pelvis through the great sciatic foramen between the pyriformis and the gluteus medius, it divides into two large branches for the supply of the gluteal muscles. Of these, the *superficial* proceeds forwards between the gluteus maximus and medius, both of which they supply, and eventually anastomose with the posterior sacral and sciatic arteries; the other — the *deep* — after a short course, divides into two branches: one — the superior — curves forwards along the origin of the gluteus minimus, towards the anterior part of the ilium, to anastomose with the ascending branches of the external circumflex and the circumflex iliac arteries; the other — the inferior branch — crosses obliquely over the gluteus minimus towards the insertion of this muscle, and anastomoses with the external and internal circumflex arteries.

The nerve which accompanies the gluteal artery is the *superior gluteal nerve*, a branch of the lumbo-sacral cord. It passes out above the pyriformis, and divides into two branches — a superior and an inferior branch; the *superior branch* accompanies the corresponding branch of the gluteal artery, and supplies the gluteus medius and minimus; the *inferior branch* accompanies the inferior branch of the gluteal artery, and distributes filaments to the gluteus medius and minimus, and the tensor

* *Phil. Med. Journal*, Prize Contest, Jan. 1, 1899. Dr. Eb. W. Thomas.

fasciæ femoris. In some subjects it sends a branch to the gluteus maximus; but this muscle is chiefly supplied by the lesser sciatic nerve.

A surgeon ought to be able to cut down and tie the gluteal artery as it emerges from the pelvis. The following is the best rule * for finding it: —

Draw a line from the posterior superior spine of the ilium to the trochanter major, rotated inwards. The junction of the upper with the middle third of this line lies over the artery as it emerges from the upper border of the great sciatic notch.

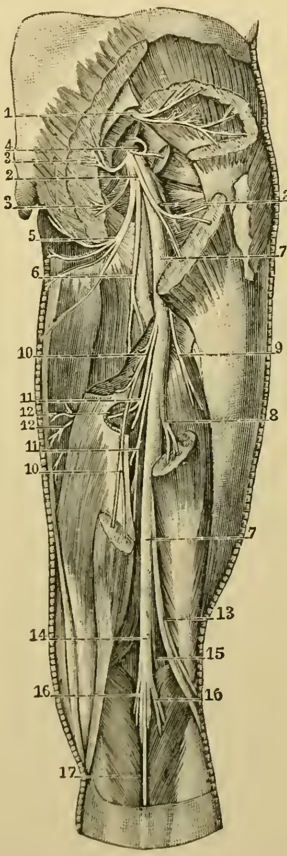
Now examine the series of muscles which rotate the thigh outwards, — namely, the pyriformis, the obturator internus, the gemelli, the quadratus femoris, and the obturator externus.

Pyriformis. — This muscle lies immediately below and parallel with the lower fibres of the gluteus medius (Fig. 242, 7). It *arises* within the pelvis by three fleshy fasciculi from the second, third, and fourth segments of the front surface of the sacrum between the foramina for the sacral nerves, from the margin of the great sacro-sciatic notch, and from the great sacro-sciatic ligament. The fibres, passing horizontally outwards, converge to a tendon, which is *inserted* into the upper border of the great trochanter. Its *nerve* comes from the sacral plexus. Its action is that of an abductor and an external rotator of the femur; and, if the femur be the fixed point, it steadies the pelvis on the femur, and when the pelvis has been drawn backwards, it will bring it forwards. The *action* when the femur is *vertical* produces external rotation, abduction, and very slight extension. With the femur horizontal, abduction, internal rotation, and very slight extension may be produced.

Obturator Internus. — This muscle, of which little more than the tendon can be seen at present, *arises* within the cavity of the pelvis, from the inner surface of the ischium, bounded posteriorly by the margin (Fig. 242, 8) of the great sacro-sciatic notch and the articular surface for the sacrum, and superiorly by the brim of the true pelvis; from the obturator membrane, and the obturator fascia; in front, from the inner surface of the descending ramus of the os pubis and the ascending ramus of the ischium. The fibres are directed backwards and outwards, and terminate on four tendons which converge towards the lesser sacro-sciatic notch; pass through the foramen of the same

* The operation of tying the gluteal artery was first performed by John Bell. See his *Principles of Surgery*, vol. i., p. 421.

name at nearly right angles, as round a pulley, and then unite into a single tendon to be *inserted* into the top of the great trochanter, in front of the pyriformis. Divide the tendon about three inches from its insertion, to see the four tendons which play over the smooth cartilaginous surface on the inner side of



1. Superior gluteal nerve.
2. Inferior gluteal or lesser sciatic.
3, 3, 3. Its branch to the gluteus maximus.
4. Branch to the pyriformis.
5. Genital branch of the lesser sciatic.
6. Femoro-popliteal of the same nerve.
7, 7. Trunk of the great sciatic.
8, 9. Branch to the long and short heads of the biceps.
10, 10. Branch to the semitendinosus.
11, 11. Branches to the semi-membranosus.
12, 12. Branch to the adductor magnus.
13. External popliteal or peroneal.
14. Internal popliteal.
15. Filament to the plantaris muscle.
16, 16. Branches to the gastrocnemius.
17. Origin of the external saphenous nerve.

FIG. 243.—THE GREAT SCIATIC NERVE, WITH ITS COLLATERAL AND TERMINAL BRANCHES.

the tuberosity of the ischium. There is a large synovial bursa to diminish friction. The *nerve* to this muscle comes from the sacral plexus (sometimes from the pudic) within the pelvis; it emerges from the great sacro-sciatic foramen, winds round the spine of the ischium, and re-enters the pelvis through the

lesser sacro-sciatic foramen to supply the muscle on its inner surface. The action of this muscle is to rotate the femur outwards; but, in the sitting position, it loses this action, and becomes an abductor of the thigh. When the femur is vertical, its action will be that of external rotation, adduction, flexion, and extension. With the femur horizontal, that of abduction, external rotation, and extension.* Between the capsule of the hip-joint and the tendon a synovial bursa is commonly found, which not infrequently communicates with the bursa placed between the tendons and the tuberosity of the ischium.

Gemelli. — These small muscles are accessory to the obturator internus, and are situated one above, the other below it. The *gemellus superior* (Fig. 242), the smaller of the two, and occasionally absent, *arises* from the outer surface of the spine of the ischium; the *gemellus inferior* from the upper and back part of the tuberosity of the ischium. Their fibres, attached to the tendon of the obturator internus, are *inserted* with it into the upper border of the great trochanter. The *nerves* to these muscles come from the sacral plexus; that to the superior gemellus from the lower part of the plexus; that to the inferior gemellus comes out through the great sacro-sciatic foramen, passes beneath the superior gemellus and obturator internus to enter the muscle on its deep aspect; this branch also distributes a filament to the quadratus femoris, and another to the hip-joint.

Quadratus Femoris. — This quadrilateral muscle *arises* (Fig. 242, 11) from the ridge on the outer border of the tuber ischii. Its fibres run horizontally outwards, and are *inserted* into the back of the great trochanter, into the greater part of the linea quadrati. The lower border of the quadratus femoris runs parallel with the upper edge of the adductor magnus; in fact, it lies on the same plane. Between these muscles is generally seen a terminal branch of the internal circumflex artery. Its *nerve*, as previously described, comes from the sacral plexus, and enters its deep surface. The *action* of this muscle with the femur *vertical* produces external rotation, adduction, flexion, and extension: with the femur *horizontal* abduction, external rotation, and extension. The change of this muscle from that of flexion to extension may be noted in going upstairs, and may occur when walking on the level.

* Lit. cit.: Dr. Eb. W. Thomas.

Obturator Externus. — To see this muscle, reflect the quadratus femoris from its origin. It *arises* from the outer surface (Fig. 231, 4) of the body of the os pubis, from the front surface of the rami of the os pubis and ischium, which form the inner border of the obturator foramen, from the inner two-thirds of the outer surface of the obturator membrane, and from the tendinous arch over the obturator vessels. Its fibres converge to a tendon which runs horizontally outwards over a groove on the ischium, and, running across the back of the hip-joint, is *inserted* into the deepest part of the trochanteric fossa of the femur. Its *nerve* is a branch of the posterior division of the obturator nerve. This muscle has *in front* of it the adductor longus and brevis, the pectineus, the psoas and iliacus, the neck of the femur, and the capsular ligament; *above* it are the capsular ligament and the inferior gemellus; *below* it are the adductor magnus and quadratus femoris; *behind* it are the obturator membrane and the quadratus femoris. The *action* of this muscle with the femur vertical produces external rotation, adduction, and flexion; with the femur horizontal adduction, external rotation, and extension.

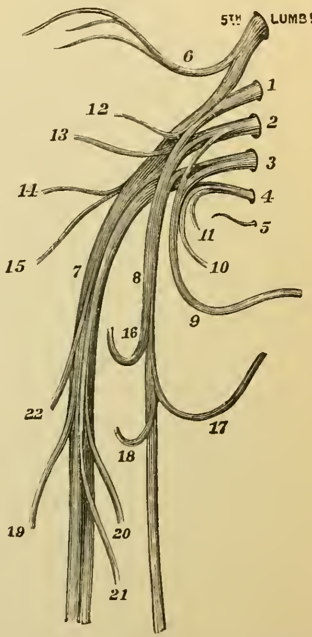


FIG. 244. — PLAN OF THE SACRAL PLEXUS AND BRANCHES.

1, 2, 3, 4, 5. Sacral nn. 6. Superior gluteal n. 7. Great sciatic n. 8. Lesser sciatic n. 9. Pudic n. 10. N. of obturator internus. 11. N. of levator ani. 12. N. of pyriformis. 13. N. of gemellus superior. 14. N. of gemellus inferior. 15. N. of quadratus femoris. 16. N. of gluteus maximus. 17. Long pudendal n. 18. Cutaneous n. of the buttock. 19. N. of the long head of the biceps. 20. N. of semi-tendinosus. 21. N. of semi-membranosus. 22. N. of short head of the biceps.

Great Sciatic Nerve. — This large nerve, formed by the union of the last lumbar and the four upper sacral nerves (Fig. 244), is the largest nerve in the body, being three-quarters of an inch (*18 mm.*) in breadth, and supplies all the flexor muscles of the lower extremity and the extensors of the foot.

Emerging from the pelvis through the great sacro-sciatic foramen below the pyriformis, it descends over the external

rotator muscles of the thigh, along the interval between the tuber ischii and the great trochanter, but rather nearer to the former; so that, in the sitting position, the nerve is protected from pressure by this bony prominence. The nerve does not descend quite perpendicularly, but rather obliquely forwards upon the adductor magnus, parallel with the great sacro-sciatic ligament, and below the middle of the thigh divides into the internal popliteal and the peroneal (or external popliteal). It is accompanied by a branch of the sciatic artery, called the *comes nervi ischiatici.** The nerve distributes branches to the ham-string muscles and the adductor magnus, and sends two or more small branches to the hip-joint which pierce the posterior part of the capsular ligament (Fig. 244).

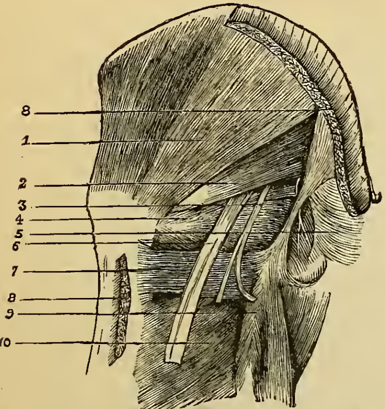


FIG. 245.—DEEP MUSCLES OF THE GLUTEAL REGION.

1. Gluteus medius. 2. Pyriformis. 3. Lesser sciatic nerve. 4. Obturator internus, with the two gemelli. 5. Coccygeus. 6. Great sciatic nerve. 7. Quadratus femoris. 8. Gluteus maximus. 9. The semi-tendinosus and biceps. 10. Adductor magnus.

Small Sciatic Nerve.—This comes from the lower part of the sacral plexus. It leaves the pelvis below the pyriformis, with the great sciatic nerve, but on the inner side of it and in company with the sciatic artery. It descends behind the gluteus maximus, and becomes cutaneous at its lower border. The muscular branches which it gives off are one or more—*inferior gluteal*—which enter the under surface of the gluteus maximus near its lower border.

All its other branches are cutaneous, and are divided into an ascending and internal group; the *ascending branches* turn round the lower border of the gluteus maximus, and supply the skin of the buttock; the *internal branches* supply the skin on the inner and posterior aspect of the thigh in its upper part; and one branch, larger than the rest, called the *inferior pudendal*, turns inwards towards the perineum to supply the skin of that region and the scrotum, commnicating with the inferior hæmorrhoidal and superficial perineal nerves. The continued trunk runs

* The arteria comes nervi ischiatici runs generally by the side of the nerve, but sometimes in the centre of it. This artery becomes one of the chief channels by which the blood reaches the lower limb after ligature of the femoral. See in the Museum of the Royal College of Surgeons a preparation in which the femoral was tied by John Hunter fifty years before the man's death.

down the back of the thigh beneath the muscular fascia, as low as the upper part of the calf, with the external saphenous vein, supplying the skin all the way down, and communicates with the short saphenous nerve.

Sciatic Artery. — This, one of the terminal branches of the internal iliac, courses along the inner aspect of the sacral plexus and pyriformis, behind the pubic artery, while this vessel is still within the pelvis. It emerges from the pelvis between the pyriformis and coccygeus, and is then seen in the gluteal region coming out between the pyriformis and superior gemellus. It then descends between the tuber ischii and the great trochanter, along the inner side of the great sciatic nerve.

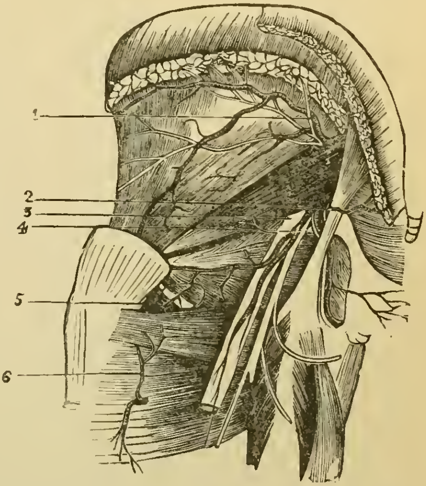


FIG. 246.—THE ARTERIES OF THE GLUTEAL REGION.

1. Gluteal artery and nerve. 2. Pudic artery and nerve, and nerve to obturator internus. 3. Great sacro-sciatic nerve. 4. Sciatic artery. 5. Internal circumflex artery. 6. The first perforating artery.

It gives off: (1) within the pelvis, branches to the muscles which form the muscular floor of the pelvis, to the rectum, the bladder, prostate and vesiculæ semi-nales; (2) external to the pelvis, it gives off: *a*, a *coccygeal branch*, which runs inwards through the great sacro-sciatic ligament, then ramifies in the gluteus maximus, and on the back of the coccyx; *b*, the *comes nervi ischiatici*, which accompanies the great sciatic nerve for a short distance, and then enters its substance; *c*, the *inferior gluteal branches*, which enter the gluteus maximus; *d*, *articular branches*, which pierce the posterior capsule of the hip-joint; *e*, *muscular branches* to the several external rotators and the hamstring muscles, and which inosculate with the external and internal circumflex, gluteal, obturator, and first perforating arteries.

Pudic Artery and Nerve. — The course of this artery and nerve has been fully described (p. 527). Observe now that they pass over the spine of the ischium accompanied by the nerve to the obturator internus, and that in a thin subject it is possible to compress the artery against the spine. The rule for finding it is this: rotate the foot inwards, and draw a line from the top of the great trochanter to the base of the coccyx; the junction of the inner with the outer two-thirds gives the situation of the artery.*

* Mr. Travers succeeded in arresting hæmorrhage from a sloughing ulcer of the glans penis by pressing the public artery with a cork against the spine of the ischium.

Popliteal Space: its Boundaries. — It is advisable to examine the popliteal space at this stage of the dissection, in order that the various parts may be carefully made out with as little disturbance as possible of their mutual relations.

Surface Marking. — The popliteal space is a lozenge-shaped hollow at the back of the knee-joint, extending as high as the junction of the middle with the lower third of the femur, and as low as the upper sixth of the tibia. The hollow is most apparent when the knee is flexed, as then the tendinous boundaries stand out in bold relief; it is almost lost when the leg is extended. The tendon on the outer side is that of the biceps, diverging to the head of the fibula; on the outer side, and below, are the plantaris and outer head of the gastrocnemius, which are not well defined; on the inner side, above, we can feel three tendons in the following order from within outwards — the semi-tendinosus, the semi-membranosus and the gracilis; below, on their inner side, is the inner head of the gastrocnemius. The upper angle of this space is formed by the diverging biceps and semi-tendinosus; the lower angle by the converging heads of the gastrocnemius. Passing from above downwards in the middle of the space, and in the following order, are the internal popliteal nerve, the popliteal vein and artery; and along the inner border of the biceps can be felt the external popliteal nerve. Filling up the hollow is a quantity of soft fat, with some lymphatic glands, and on the bone rest the articular arteries.

Dissection. — A vertical incision must be made along the middle of the ham, extending from six inches (*15 cm.*) above, to three inches (*7.5 cm.*) below the knee; transverse incisions should be made at each extremity of the vertical, so that the skin may be conveniently reflected. In doing so, care must be taken to preserve the cutaneous branch of the lesser sciatic nerve, which descends over the space to the back of the leg.

The muscular fascia covering the space is very strong, and strengthened by numerous transverse fibres. It is pierced by the posterior saphena vein, which passes in to join the popliteal vein.

The fascia having been reflected, the muscles and tendons constituting the boundaries of the popliteal space are to be cleaned. The boundaries of the space can now be seen to be formed, as before stated, above, by the divergence of the hamstring muscles to reach their respective insertions; below, by the converging heads of the gastrocnemius; its shape is there-

fore that of a lozenge. Above, it is bounded on the inner side by the semi-tendinosus, semi-membranosus, gracilis, and sartorius; on the outer side, by the biceps; below, it is bounded on the inner side by the internal head of the gastrocnemius; on the outer, by the external head of this muscle and the plantaris.

The space is occupied by a quantity of fat, which permits the easy flexion of the knee; and in this fat are found the popliteal vessels and nerves, in the following order: nearest to the surface are the nerves; the artery lies close to the bone, the vein being superficial to the artery (Fig. 247, p. 654).

Great Sciatic Nerve. — Along the outer border of the semi-membranosus, and covered by the long head of the biceps, is the great sciatic nerve, which, after giving off branches to the three great flexor muscles and the adductor magnus, divides, about the lower third of the thigh (higher or lower in different subjects), into two large nerves — the peroneal or external popliteal and the internal popliteal.

The *peroneal nerve* runs close by the inner side of the tendon of the biceps*, and subsequently in the groove between this muscle and the outer head of the gastrocnemius, towards the head of the fibula. As it passes round the joint it gives off *two articular* (Fig. 240, p. 639) branches to the outer side of the knee, which accompany the external superior and inferior articular arteries, and a *recurrent articular* branch, which runs with the recurrent tibial artery to the front of the knee. It supplies also two or three *cutaneous branches* to the posterior and outer surfaces of the leg, as far as its middle third.

The *communicans peronei* (Fig. 247) is a small branch given off as the nerve passes over the gastrocnemius; it crosses the outer head of this muscle and joins the external saphenous, which runs down the back of the calf, and behind the external malleolus, to supply the outer side of the foot and little toe.

Below the head of the fibula we have already traced the division of the peroneal into the anterior tibial, and the musculo-cutaneous nerves (p. 640).

The *internal popliteal nerve*, the larger of the two divisions of the great sciatic nerve, accompanies the popliteal artery, and, at the lower border of the popliteus, it is continued under the name of the posterior tibial. The nerve in the popliteal space lies

* The nerve is, therefore, very liable to be injured in the operation of dividing the outer hamstring. In the diagram the nerve is not near enough to the tendon, their connections having been severed.

superficial to and rather external to the artery, and gives off four or five *muscular branches* which supply the two heads of the gastrocnemius, the plantaris, the soleus, and the popliteus; *three articular* branches, two accompanying the internal superior and inferior articular arteries, the third piercing the back of the capsule accompanied by the azygos artery; and the *short* or *external saphenous*, which descends in the groove between the

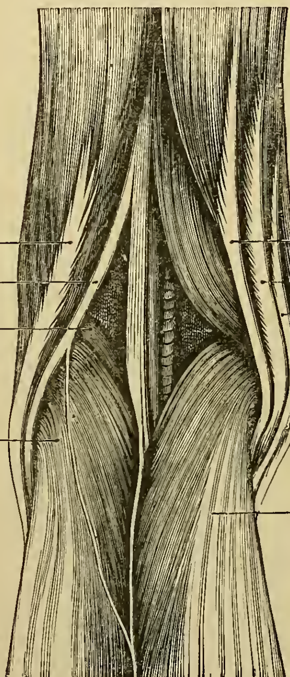


Fig. 247.—Left Popliteal Space.

two heads of the gastrocnemius, is joined about the middle of the leg by the communicans peronei, and then, running down behind the outer malleolus in company with the external saphena vein, is distributed to the outer side of the foot and the little toe. The continuation of the internal popliteal nerve, as posterior tibial, supplies all the flexor muscles on the back of the leg and the sole of the foot.

Popliteal Vessels. — By clearing out all the fat, we observe that the popliteal vessels enter the ham through an aperture in the adductor magnus, and descend close to the back part of the

femur, and the back of the knee-joint. At first they are partially overlapped (in muscular subjects) by the semi-membranosus; indeed, the outer border of this muscle is a good guide to the artery in the operation of tying it. The *popliteal artery* lies upon the triangular surface at the back of the lower third of the femur; then, upon the ligamentum posticum Winslowii; and, lastly, upon the popliteus, at the lower border of which it divides into the anterior and posterior tibial.

Superficial to the artery are the semi-membranosus, a considerable amount of fat, the gastrocnemius, the plantaris, the soleus, the popliteal vein, and the internal popliteal nerve; *internally*, it has the semi-membranosus, the internal condyle of the femur, and the inner head of the gastrocnemius; *externally*, it has the biceps, the external condyle, the outer head of the gastrocnemius, and the plantaris.

The artery gives off the *external* and *internal superior articular arteries;* lower down, the *external* and *internal inferior articular arteries*, the *superior* and *inferior muscular branches*, the *azygos*, and *cutaneous branches*. The description of these branches of the popliteal will be deferred till later, until the muscles of the calf have been reflected.

The articular branches which come from the popliteal are given off at right angles to that vessel; and besides these it gives off the *sural*, which supply the muscles of the calf, and the azygos artery; close to the vessel is the articular branch of the obturator nerve, which supplies the knee-joint.

The *popliteal vein* lies superficial or posterior to the artery, and rather to its outer side. It receives the short saphena vein. Its coats are remarkably thick, and on transverse section resemble those of an artery of a similar size.

Lymphatic Glands. — Two or more lymphatic glands are situated one on each side of the artery. They deserve attention, because, when enlarged, their close proximity to the artery may communicate a pulsation which might be mistaken for an aneurism.

DISSECTION OF THE BACK OF THE THIGH.

Dissection. — The incision should be continued along the remainder of the back of the thigh, and the skin reflected. The fat should be removed, and the cutaneous branches derived from the external and internal cutaneous nerves, and the small sciatic, should be carefully sought out.

Cutaneous Nerves and Veins. — The skin on the middle of the back of the thigh is supplied by the small sciatic nerve, which runs down beneath the deep fascia as far as the middle third; then pierces it, and runs down as far as the middle third of the calf, distributing branches on each side. On the outer side, a few cutaneous branches from the *posterior division* of

the *external cutaneous nerve* supply the skin as far as the middle third; on the inner side are small branches from the small sciatic and the internal cutaneous nerves as low as the knee-joint.

The subcutaneous veins at the back of the thigh are very small; here they would be liable to pressure. But near the popliteal space there is a vein, called the *external* or *short saphena.* It comes up the back of the calf, and joins the popliteal vein after perforating the strong fascia covering the space.

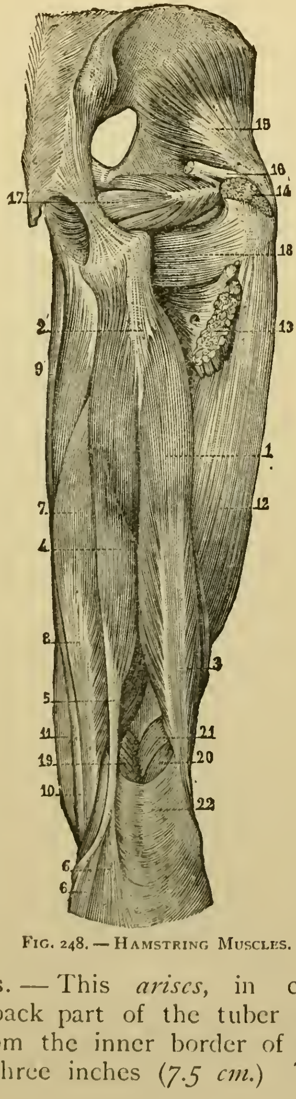
Muscular Fascia. — Respecting this, remark that its fibres run chiefly in a transverse direction, that it becomes stronger as it passes over the popliteal space, and that here it is connected with the tendons on either side. Remove it, to examine the powerful muscles which bend the leg, called the hamstrings.

Hamstring Muscles. — There are three of these, and all arise by strong tendons from the tuber ischii. One, the biceps, passes downwards and outwards to be inserted into the head of the fibula; the other two — namely, the semi-tendinosus and semi-membranosus — descend inwards and are inserted into the tibia. The divergence of these muscles towards their respective insertions occasions the space termed the *popliteal*, which is occupied by soft fat, the popliteal vessels, nerves, and lymphatic glands.

Biceps. — This muscle has two origins, a long and a short. The *long head arises*, by a strong tendon, from the back part of the tuber ischii in common with the semi-tendinosus; the *short head*, by fleshy fibres, from the outer lip of the linea aspera of the femur between the vastus externus and the adductor magnus, and from the external intermuscular septum: this origin begins at the linea aspera, just below the insertion of the gluteus maximus, and continues nearly down to the external condyle. It joins the long head of the muscle, and both terminate on a common tendon, which is *inserted* into the outer side of the head of the fibula, by two portions separated by the external lateral ligament of the knee-joint. It also gives off a strong expansion to the fascia of the leg. The tendon covers part of the external lateral ligament of the knee-joint, and a small bursa intervenes.

The biceps is not only a flexor of the leg, but rotates the leg, when bent outwards, and in both positions performs extension and adduction. It is the muscle which in chronic disease of

the knee dislocates the leg outwards and backwards, and at the same time rotates it outwards. Each head of the biceps is supplied by the great sciatic nerve. The short head is sometimes supplied by the peroneal.

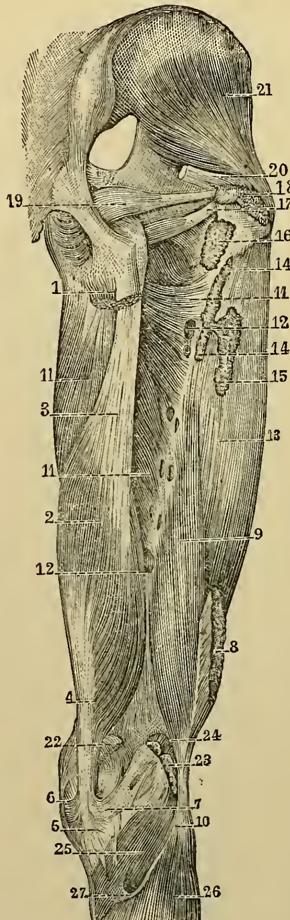


1. Long head of the biceps.
2. Common tendon for the origin of biceps (long head) and the semitendinosus attached to the tuberosity of the ischium.
3. Inferior tendon of the biceps.
4. Semitendinosus.
5. Its tendon.
6, 6. Expansion of this tendon into the aponeurosis of the leg.
7. Semimembranosus.
8. Its inferior tendon.
9. Gracilis.
10. Its tendon.
11. Sartorius.
12. Vastus externus.
13. Femoral attachment of the gluteus maximus.
14. Insertion of the gluteus medius.
15. Gluteus mimimus.
16. Tendon of the pyriformis.
17. Tendon of the obturator internus, on either side of which are attached the gemelli.
18. Quadratus femoris.
10. Internal head of the gastrocnemius.
20. External head.
21. Plantaris.
22. Popliteal aponeurosis.

Fig. 248. — Hamstring Muscles.

Semitendinosus. — This *arises*, in common with the biceps, from the back part of the tuber ischii by muscular fibres and also from the inner border of the tendon of the biceps for about three inches (*7.5 cm.*) The muscle passes

downwards and inwards, and terminates in the middle of the thigh in a long round tendon, which rests upon the semimembranosus, and is *inserted* into the upper part of the inner surface of the tibia by an expanded tendon, below the tendon of the



1. Common tendon of origin for the biceps, semitendinosus, and semimembranosus.
2. Semimembranosus.
3. Its superior tendon.
4. Its inferior tendon.
5. Middle portion of this tendon.
6. Its anterior part.
7. Its posterior part.
8. Cut long head of the biceps.
9. Its short head.
10. Insertion of the biceps to the head of the fibula.
11, 11, 11. Adductor magnus.
12, 12. Vascular foramina.
13. Vastus externus.
14, 14. Insertion of the gluteus maximus.
15. Severed insertion of the above into the fascia of the thigh.
16. Insertion of the quadratus femoris.
17. Tendon of the obturator externus.
18. Insertion of the gluteus medius.
19. Obturator internus.
20. Tendon of the pyriformis.
21. Gluteus minimus.
22. Cut internal head of the gastrocnemius.
23. Cut external head.
24. Cut plantaris.
25. Popliteus.
26. Soleus.
27. Ring made by the soleus.

FIG. 249.—SHORT HEAD OF THE BICEPS AND SEMIMEMBRANOSUS, MUSCLES.

gracilis, and behind that of the sartorius. Like them, it plays over the internal lateral ligament of the knee, and is provided with a bursa. Its *nerve* comes from the great sciatic.

The semitendinosus sends off from the lower border of its tendon a very strong fascia to cover the leg, which is attached along the inner edge of the tibia. The middle of the muscle is usually intersected by an oblique tendinous line. The *action* of this muscle with the femur *vertical* performs internal rotation, adduction, extension, and the same functions plus external rotation with the leg at 90°. With the femur *horizontal* the same functions, whether the leg is at 90° or in the same axis as the femur.*

Semimembranosus. — This muscle *arises* from the upper and outer facet on the back of the tuber ischii, above and external to the two preceding, by means of a strong flat tendon, which extends nearly half-way down the thigh. This tendon descends obliquely under the biceps and semitendinosus, and terminates in a bulky muscle, which lies on a deeper plane, and more internal than the others, and is *inserted* by a thick tendon into the posterior and inner part of the internal tuberosity of the head of the tibia. In connection with the insertion of this tendon, notice, (1) that from its inner side a strong fasciculus is prolonged forwards under the internal lateral ligament of the knee, and that a bursa intervenes between them ; (2) that from its outer and posterior part it sends a strong prolongation upwards and outwards to the back part of the external condyle of the femur, forming the principal portion of the *ligamentum posticum Winslowii*, which covers the back of the knee-joint ; (3) that a dense fascia proceeds from its lower border, and binds down the popliteus ; (4) that it is intimately connected with the semilunnar cartilages of the joint, so as to keep them in place during its movements. Its *nerve* comes from the great sciatic.

A great *bursa* is almost invariably found between the semimembranosus and the inner head of the gastrocnemius, where they rub one against the other. It is generally from one and a half to two inches (*3.8 to 5. cm.*) long. The chief point of interest concerning it is, that it occasionally communicates with the synovial membrane of the knee-joint, not directly, but through the medium of another bursa beneath the inner head of the gastrocnemius. From an examination of 150 bodies, it appers that this communication exists about once in five times ; and it need scarcely be said that the proportion is large enough to

* Loc. cit.; Dr. Eb. W. Thomas.

make us cautious in interfering with this bursa when it becomes enlarged.* The *action* of the muscle with the femur *vertical* performs internal rotation, external rotation, adduction, and extension, and the same functions with the leg at 90°. With the femur *horizontal*, adduction, internal rotation, external rotation, and extension, whether the leg is at 90° or in the same axis as the femur.*

Action of the Hamstring Muscles. — These muscles produce two different effects, according as their fixed point is at the pelvis or the knee. With the fixed point at the pelvis, they bend the knee; with the fixed point at the knee, they take a very important part in maintaining the body erect. For instance, if, when standing, the body be bent at the hip, and the muscles in question be felt, it will be found that they are in strong action, to prevent the trunk from falling forwards; they, too, are the chief agents concerned in bringing the body back again to the erect position. In doing this, they act upon a lever of the first order, as shown in Fig. 250; the acetabulum being the fulcrum F, the trunk W, the weight to be moved, and the power P at the tuber ischii.

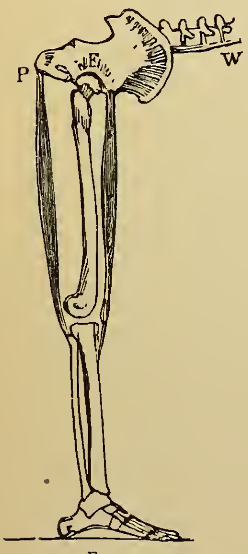


FIG. 250.

To put the action of the muscles of the thigh on the pelvis in the clearest point of view, let us suppose we are standing upon one leg: the bones of the lower extremity represent a pillar which supports the weight of the trunk on a ball-and-socket joint; the weight is nicely balanced on all sides, and prevented from falling by four groups of muscles. In front, are the rectus and sartorius; on the inner side, the adductors; on the outer side, the gluteus medius and minimus; behind, the hamstrings and gluteus maximus.

When the knee is semi-flexed, the semimembranosus can also

* When the bursa in question becomes enlarged, it occasions a fluctuating swelling of greater or less dimensions on the inner side of the popliteal space. The swelling bulges out, and becomes tense and elastic when the knee is extended, and *vice versâ*. As to its shape, it is generally oblong; but this is subject to variety, for we know that the bursæ, when enlarged, are apt to become multilocular, and to extend between the muscles where there is the least resistance.

rotate the leg inwards, thus assisting the popliteus ; the biceps can also in the same position of the knee rotate the leg slightly outwards.

The hamstring muscles are supplied with blood by the perforating branches of the profunda, which come through the tendon of the adductor magnus close to the femur, and by muscular branches from the popliteal artery. The nerves are derived from the great sciatic.

Great Sciatic Nerve. — This nerve descends from the gluteal region upon the adductor magnus, and, after being crossed by the long head of the biceps, runs along the outer border of the semimembranosus down the popliteal space. The great sciatic divides into its two terminal divisions at a variable distance from its exit through the great sciatic foramen, sometimes high up, occasionally lower down than usual. The further course of this nerve has already been described (p. 653).

Deferring the course, relations, and branches of the popliteal artery till this vessel is exposed throughout its whole course, pass on now to the dissection of the calf.

DISSECTION OF THE BACK OF THE LEG.

Surface Marking. — The back of the leg gradually narrows from above downwards so as to form a long cone ; the upper half is convex and fleshy, corresponding to the gastrocnemius and the soleus muscles ; the lower half suddenly diminishes, so that the posterior borders of the tibia and fibula can be easily felt extending to their respective malleoli. In a well-developed subject with not much fat the two heads of the gastrocnemius can be seen through the skin, the inner head being the broader and lower of the two ; the tendon into which they are inserted (tendo Achillis) rapidly narrows to be attached to the posterior and upper part of the tuberosity of the os calcis. On the inner and outer sides of the lower part of this tendon there is a well-defined vertical groove, bounded laterally by the tibia and fibula. In cases of synovial disease of the ankle-joint these grooves are lost, so that instead of a depression there is a convexity. In these grooves can be felt the tendons passing round the ankle behind the malleoli ; on the inner side are the tibialis posticus, flexor longus digitorum, and flexor longus hallucis ; on the outer side are the peronei longus and brevis.

Continue the incision down the centre of the calf to the heel, where a transverse incision must also be made. The skin should now be reflected, taking care of the subcutaneous veins and nerves.

Short or Posterior Saphena Vein.—The large vein seen in the middle of the back of the leg is called the *short* or *posterior saphena.* It commences on the outer side of the dorsum of the foot, ascends behind the outer ankle, where it has a communication with the deep veins, and then runs up the calf between the two bellies of the gastrocnemius, receiving numerous veins in its course, and being guarded by several valves. It eventually passes through the muscular fascia, and joins the popliteal vein.

Cutaneous Nerves.—The back of the leg is supplied by cutaneous nerves: in the middle, above, by the small sciatic nerve, and below, by the short or external saphenous; on the outer side, by the communicans peronei; and on the inner side, by branches from the internal saphenous nerve.

Short or External Saphenous Nerve.—The *short saphenous* nerve* is derived from the internal popliteal nerve (Figs. 240–247), and passes down beneath the deep fascia between the two heads of the gastrocnemius to the middle of the calf, where it pierces the fascia. Here it is joined by a branch from the peroneal nerve (*communicans peronei*); it then descends with the short saphena vein, usually on its fibular side, and is finally distributed to the outer side of the foot and the little toe.

To expose the muscles of the calf, reflect the muscular fascia by incisions corresponding to those made through the skin.

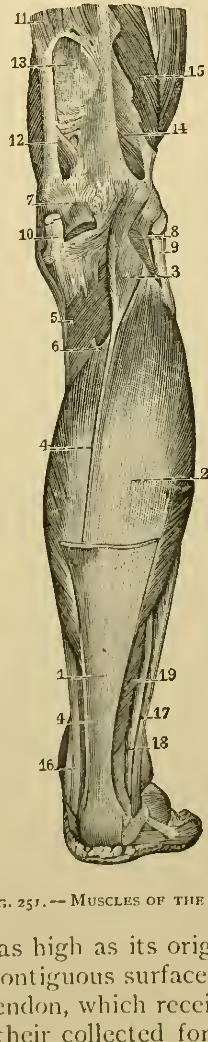
Muscles of the Calf.—The great flexor muscle of the foot consists of two portions: the superficial one, called the gastrocnemius, *arises* from the lower end of the femur; the deep one, called the soleus, *arises* from the tibia and fibula. They are attached to one thick tendon, called the tendo Achillis, which is *inserted* into the os calcis.

Gastrocnemius.—This muscle arises by two strong tendinous heads from the back of the condyles of the femur (Fig. 251). The inner head is the larger, longer, and more muscular, and *arises* from a depression at the upper and back part of the internal condyle, and, for a short distance, by fleshy fibres from the line leading from the linea aspera to the internal condyle; the outer head from the back and upper part of the external condyle above the popliteus, and also from the line leading to the linea aspera. The two parts of the muscle descend, distinct from each other, and form the two bellies of the calf, of which

* This nerve is sometimes called the *communicans poplitei*, and does not take the name of short saphenous nerve till its junction with the *communicans peronei* (p. 653).

the inner is rather the lower. Both *terminate*, rather below the middle of the leg, on the broad commencement of the tendo Achillis.

The gastrocnemius should be divided transversely near its attachment to the tendo Achillis, and reflected upwards from



1. Tendo Achillis.
2. Soleus.
3. Plantaris.
4. Its tendons.
5. Popliteus.
6. Annular fibres of the soleus.
7. Origin of the inner head of the gastrocnemius.
8. Same of the outer head.
9. Tendon of the biceps.
10. Tendon of the semi-membranosus.
11. Adductor magnus.
12. Its tendon.
13. Lower opening of Hunter's canal.
14. External intermuscular septum.
15. Vastus externus.
16. Tendon of the flexor longus digitorum.
17. Tendon of the peroneus longus.
18. Tendon of the peroneus brevis.
19. Flexor longus hallucis.

FIG. 251. — MUSCLES OF THE CALF.

the subjacent soleus, as high as its origin. By this proceeding you observe that the contiguous surfaces of the muscles are covered by a glistening tendon, which receives the insertion of their fibres, and transmits their collected force to the tendo Achillis.

Observe also the large sural vessels and nerves (branches of the popliteal) which enter the mesial aspect of each head of the muscle. To facilitate the play of the inner tendon over the condyle, there is a bursa, which generally communicates with the knee-joint; and in the substance of the outer tendon is commonly found a small piece of fibro-cartilage. Lastly, between the gastrocnemius and soleus is the tendon of the plantaris.

Plantaris. — This small muscle * *arises* from the rough line leading from the linea aspera to the outer condyle of the femur, and from the posterior ligament of the knee-joint. It descends close to the inner side of the outer head of the gastrocnemius, having a fleshy belly for about two inches (*5 cm.*), and *terminates*, a little below the knee, in a long, thin tendon, which can be traced down the inner border of the tendo Achillis to the calcaneum. This muscle is occasionally absent. Its *nerve* comes from the internal popliteal.

Soleus. — This muscle *arises* by tendinous fibres from the head and from the upper third of the posterior surface of the fibula, from the oblique ridge on the back of the tibia,† from about the middle third of the inner border of this bone, and from an aponeurotic arch thrown over the posterior tibial vessels. The muscular fibres bulge out beyond the gastrocnemius, and *terminate* on a broad tendon, which, gradually contracting, forms a constituent part of the tendo Achillis. The muscle lies upon the flexor longus digitorum, the tibialis posticus, the flexor longus hallucis, and the posterior tibial vessels and nerve. The soleus is supplied with blood by several branches from the posterior tibial; also by a large branch from the peroneal. Its *nerve* comes from the internal popliteal and enters the top of the muscle. This is an important muscle in a surgical point of view, for two reasons — (1) by reflecting its tibial origin, we can reach the posterior tibial artery; (2) by reflecting its fibula origin we can reach the peroneal.

The *tendo Achillis*, the common tendon of the gastrocnemius and soleus, begins about the middle of the leg, and is at first of

* This is the representative of the palmaris longus of the forearm. In man it is lost on the calcaneum, but in monkeys, who have prehensile feet, it is the proper tensor muscle of the plantar fascia. It is remarkably strong in bears and plantigrade mammals.

† The tibial and fibular origins of the soleus constitute what some anatomists describe as the two heads of the muscle. Between them descend the popliteal vessels, protected by a tendinous arch.

considerable breadth, but it gradually contracts and becomes thicker as it descends. The narrowest part of it is about one inch and a half (*3.8 cm.*) above the heel; here, therefore, it can be most conveniently and safely divided for the relief of club-foot. There is no risk of injuring the deeper-seated parts, because they are separated from the tendon by a quantity of fat. Its insertion is into the under and back part of the tuberosity of the os calcis. The tendon previously expands a little; between it and the bone is a bursa of considerable size.

The *action* of the gastrocnemius and soleus is to raise the body on the toes. Since the gastrocnemius passes over two joints, it has the power (like the rectus) of extending the one while it bends the other, and it is, therefore, admirably adapted to the purpose of walking. For instance, by first extending the foot it raises the body; and then, by bending the knee, it transmits the weight from one leg to the other. Supposing the fixed point to be at the heel, the gastrocnemius is also concerned in keeping the body erect, for it keeps the tibia and fibula perpendicular on the foot, and thus counteracts the tendency of the body to fall forwards.

The tendo Achillis, in pointing the toes, acts upon a lever of the *first* order. The fulcrum is at the ankle-joint, F (Fig. 250); the resistance, W, at the toes; the power at the heel, P. All the conditions are those of a lever of the first order. The power and the weight act in the *same* direction on *opposite* sides of the fulcrum. In raising the body on tiptoe, the tendo Achillis acts as a lever of the second order; the fulcrum being then at the ball of the great toe, and the weight of the body at the ankle.

Course and Relations of the Popliteal Artery.—After passing through the opening in the tendon of the adductor magnus, the femoral artery takes the name of *popliteal*. It descends nearly perpendicularly behind the knee-joint, between the origins of the gastrocnemius, as far as the lower border of the popliteus, where it divides into the anterior and posterior tibial. In its descent it *lies*, first, upon the lower part of the femur, and here it is slightly overlapped by the semi-membranosus; next, it lies upon the posterior ligament of the knee-joint; and, lastly, upon the popliteus. At its lower part the artery is covered, at first by the semi-membranosus, the popliteal vein, the internal popliteal nerve, and a considerable amount of fat; then, lower down, by the gastrocnemius and soleus, and it is crossed by the plantaris. The vein closely

accompanies the artery, and is situated superficially with regard to it, and rather to its outer side in the first part of its course. The internal popliteal nerve runs also in a similar direction with the vein, but is still more superficial and to the outer side (Fig. 247). The vessels and the nerve are surrounded by fat, and one or two lymphatic glands are generally found in the immediate neighborhood of the artery, just above the joint.

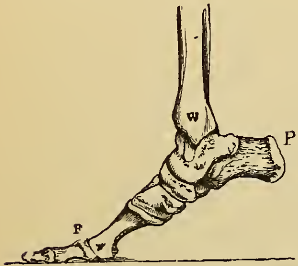


Fig. 252.

The branches of the popliteal artery are—the *articular*, the *sural*, and the *cutaneous*.

There are five *articular branches* for the supply of the knee-joint and the articular ends of the bones; the two *superior*—*external* and *internal*—run, one above each condyle, close to the bone; the two *inferior*—*external* and *internal*—run below the joint.

1. The *superior external articular* artery runs above the external condyle, passes beneath the biceps, and through the intermuscular septum: it then divides into a superficial and a deep branch; the superficial supplies the vastus externus, and then forms part of the patellar arterial plexus; the deep branch keeps close to the femur and supplies the knee, forming an arch above the joint with a branch from the anastomotica magna.

2. The *superior internal articular* artery runs above the internal condyle, under the tendon of the adductor magnus and vastus internus, and divides into two branches, a superficial and a deep, which take a corresponding course to those on the outer side.

3. The *inferior external articular* artery runs under the gastrocnemius, over the popliteus, then, passing beneath the external lateral ligament and the tendon of the biceps, it reaches the patella, where it breaks up into branches anastomosing with the other articular arteries, and the recurrent branch of the anterior tibial artery.

4. The *inferior internal articular* artery runs between the tuberosity of the tibia and the internal lateral ligament, and supplies the inner and anterior part of the joint.

5. The *azygos* artery is given off from the deep aspect of the popliteal, pierces the ligamentum posticum Winslowii, to supply the crucial ligaments and the synovial membrane.

The several articular arteries form over the front and sides of the joint a network of vessels, which anastomose, superiorly, with the descending branch of the external circumflex and the anastomotica magna; inferiorly, with the anterior tibial recurrent; and also among themselves. It is mainly through these channels that the collateral circulation is established in the leg after ligature of the superficial femoral.

The *sural arteries* proceed one to each head of the gastrocnemius, and are proportionate in size to the muscle; one or two branches are distributed to the soleus. These arteries are accompanied by branches of the internal popliteal nerve for the supply of the muscles.

The *superior muscular* branches supply the vasti and hamstring muscles, and inosculate with the perforating and articular arteries.

Cutaneous arteries pass down between the gastrocnemius and the skin supplying the integument of the calf, as far as the middle of the leg.

Popliteal Vein. — This vein is formed by the junction of the venæ comites of the anterior and posterior tibial arteries, and is situated superficial to the artery. It crosses obliquely from the inner to the outer side of the artery, and is continued upwards as the femoral. It receives in the popliteal space the short saphena, the articular, and sural veins. It is usually provided with four valves. The insertion of the tendon of the semi-membranosus into the head of the tibia, and its several connections (described p. 659), should now be fully examined.

Popliteus. — This triangular muscle *arises* (Fig. 251, 5) within the capsule of the knee-joint, from a depression on the outside of the external condyle, and from the posterior ligament of the knee, by a thick tendon, which runs beneath the external lateral ligament and the tendon of the biceps. The muscular fibres gradually spread out, and are *inserted* into the triangular surface of the tibia above the soleal ridge on the bone, and into the aponeurotic expansion covering the muscle. It is supplied by a branch of the internal popliteal nerve, which enters its deep surface. Its action is to flex the leg, and then to rotate the tibia inwards. The tendon plays over the articulation between the tibia and fibula; and a bursa intervenes, which generally communicates by a wide opening with the knee-joint. The tendinous origin grooves the external semilunar cartilage, and has an investment from the synovial membrane of the knee. The *action* of this muscle is to flex the knee feebly, and when flexed, to rotate internally and keep the posterior ligament from being pinched during flexion.

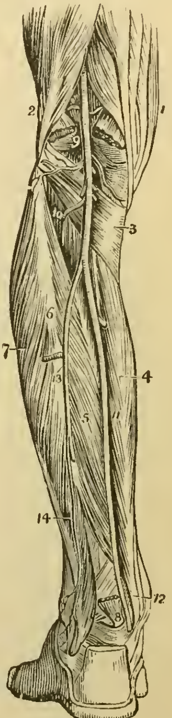


Fig. 253. — Popliteal and Posterior Tibial Arteries.

1. Tendons of the inner hamstring. 2. Tendon of the biceps. 3. Popliteus m. 4. Flexor longus digitorum. 5. Tibialis posticus. 6. Fibula, with flexor longus hallucis removed. 7. Peroneus longus and brevis. 8. Lower part of the flexor longus hallucis. 9. Popliteal artery. 10. Anterior tibial artery. 11. Posterior tibial artery. 12. Flexor and posterior tibial tendons. 13. Peroneal artery dividing into two branches. 14. Posterior peroneal artery.

Reflect the soleus from its origin, and remove it from the deep-seated muscles, observing at the same time the numerous arteries which enter its under surface. This done, notice the

deep fascia which separates the superficial and the deep layers of muscles and which binds down the deep muscles. It is attached to the margins of the tibia and the fibula on either side, increases in strength towards the ankle, and forms an *internal annular ligament* which confines the tendons and the vessels and nerves in their passage into the sole of the foot.

FIG. 254.—DEEP MUSCLES ON THE BACK OF THE LEG.

1. Femur. 2. Posterior ligament (Winslow's). 3. Tendon of semimembranosus dividing into three slips. 4. Internal lateral ligament of the knee-joint. 5. Long external lateral ligament. 6. Popliteus. 7. Flexor longus digitorum. 8. Tibialis posticus. 9. Flexor longus hallucis. 10. Peroneus longus. 11. Peroneus brevis. 12. Tendo Achillis. 13. Tendon of tibialis posticus.

The deep fascia should now be removed from the deep muscles, which must be cleaned in the course of their muscular fibres.

Deep Muscles on the Back of the Leg.—There are three: the flexor longus digitorum on the tibial side; the flexor longus hallucis on the fibular; the tibialis posticus upon the interosseous membrane, between and beneath them both.

Flexor Longus Digitorum.—This *arises* from the posterior surface of the tibia, commencing below the popliteus, and extending to within four inches (*10 cm.*) of the lower end of the bone, also from the fascial septum between it and the tibialis posticus. The fibres terminate on a tendon which is placed on the tibial side of the muscle, and it runs through a groove behind the inner ankle, lined by a special synovial sheath. It enters the sole and divides into four tendons, which are inserted into the ungual phalanges of the four outer toes. It is supplied by the posterior tibial nerve. The *action* of this muscle is to flex the four outer toes, the mid tarsal joint, to point the foot and to preserve the arch of the instep.

Flexor Longus Hallucis.—This powerful muscle *arises* from the lower two-thirds of the posterior surface of the fibula, from the septum between it and the peronei, from the lower part of the interosseous membrane, and from the aponeurosis over the tibialis posticus. The fibres terminate on a tendon

which runs through a groove on the back of the lower extremity of the tibia, then through the groove on the back of the astragalus, thence it passes through another groove on the under aspect of the sustentaculum tali, and is *inserted* into the ungual phalanx of the great toe. The chief action of this muscle is to raise the body on the tip of the great toe. It is essential to the propulsion of the body in walking, as the great toe is the last portion of the foot to leave the ground, and therefore adds great firmness to the gait of the individual. It is supplied by the posterior tibial nerve.

Tibialis Posticus. — This is so concealed between the two preceding muscles that it cannot be properly examined without reflecting them. It *arises* (Fig. 254, 8) by two processes from the interosseus membrane, between which the anterior tibial artery passes forwards, from the opposite surfaces, of the tibia and fibula for about their middle three-fifths, and from the aponeurosis covering it. In the lower part of the leg it passes between the tibia and the flexor longus digitorum. Its muscular fibres terminate on a tendon which comes into view a short distance above the inner malleolus, and, running through the same groove with the tendon of the flexor longus digitorum, enters the sole, and is *inserted* into the scaphoid and internal cuneiform bones, and by fibrous prolongations into most of the tarsal and metatarsal bones. Its *action* is to bend and turn the foot inwards. It is supplied by the posterior tibial nerve. The precise situation of the tendon of the tibialis posticus is interesting, surgically, because the tendon has to be divided for the relief of talipes varus. It lies close to, and parallel with, the inner edge of the tibia, so that this is the guide to it. It is necessary to relax the tendon, while the knife is introduced between the tendon and the bone. Its synovial sheath commences about $1\frac{1}{2}$ inch (*3.8 cm.*) above the end of the internal malleolus, and is consequently opened in the operation.

Attention should now be directed to the *internal* or *posterior annular ligament*, which binds down the tendons behind the inner ankle.

It is attached to the internal malleolus and the inner border of the os calcis. It is continuous, above, with the deep fascia of the leg, below with the plantar fascia and the adductor hallucis. Beneath it are a series of compartments through which pass the tendons of the deep-seated muscles of the leg and the vessels into the sole of the foot. The relative positions of the

structures passing under this ligament, proceeding from within outwards, are — the tendons of the tibialis posticus, and the flexor longus digitorum; the posterior tibial artery accompanied by its venæ comites; the posterior tibial nerve; and, lastly, the tendon of the flexor longus hallucis. Each of the tendons is lined by a separate synovial membrane, as they pass behind the inner ankle.

Course and Relations of the Posterior Tibial Artery. — This artery is one of the branches into which the popliteal divides at the lower border of the popliteus. It descends (Fig. 253) between the superficial and the deep muscles at the back of the leg to the interval between the internal malleolus and the os calcis, and, entering the sole, divides beneath the abductor hallucis into the external and internal plantar arteries. It lies, first, for a short distance, *upon* the tibialis posticus, then on the flexor longus digitorum; but behind the ankle it is in contact with the tibia, so that here it can be felt beating, and effectually compressed; and lastly on the back of the ankle-joint. In the upper part of its course, it runs nearly midway between the bones, and is *covered* by the gastrocnemius and soleus, and is crossed obliquely from within outwards by the posterior tibial nerve. To tie the artery, therefore, in this situation, is difficult; but in the lower part of its course it gradually approaches the inner border of the tibia, from which, generally speaking, it is not more than half or three-quarters of an inch (*13 to 18 mm.*) distant. Here, being comparatively superficial, it may easily be tied. Immediately behind the internal malleolus, it lies between the tendons of the flexor longus digitorum on the inner side, and the flexor longus hallucis on the outer. It has two venæ comites, which communicate at intervals. The posterior tibial nerve which accompanies the artery is at its upper third on its *inner side*, then crosses over it, and for the lower two-thirds of its course lies *external* to the artery. Its branches are as follows: —

a. Numerous *muscular* branches to the soleus, the peronei, and the deep muscles.

b. The *peroneal* (Fig. 253) is a branch of considerable size, — often as large as the posterior tibial. Arising about an inch (*2.5 cm.*) below the division of the popliteal, it descends close to the interosseous border of the fibula, and then over the articulation between the tibia and fibula to the outer part of the os calcis, where it inosculates with the malleolar and plantar arteries. All down the leg it is imbedded among the muscles — being covered: first by the soleus, afterwards by the flexor longus hallucis, by the fibres of which it is more or less surrounded. To both these muscles, to the latter especially, it sends numerous branches, and

just above the ankle it gives off a constant one, — the *anterior peroneal*, — which passes through the interosseous membrane to the under aspect of the peroneus tertius, then runs in front of the inferior tibio-fibular articulation, and inosculates with the other malleolar and tarsal arteries. The peroneal supplies the *nutrient* artery of the fibula.

c. The *communicating artery* passes transversely across the interosseous membrane about an inch (*2.5 cm.*) above the os calcis. It runs under the tendon of the flexor longus hallucis, and anastomoses with the peroneal artery.

d. The *internal calcanean* arteries, several in number, run down, ramifying over the posterior and inner aspect of the tendo Achillis and os calcis: they anastomose with the internal malleolar and peroneal arteries.

e. The *nutrient artery* to the tibia enters the bone about an inch (*2.5 cm.*) below the oblique line, the foramen through which it passes being directed away from the knee-joint.

The *posterior tibial veins*, formed by the junction of the external and internal plantar veins, accompany the artery as *venæ comites*, and, after receiving the peroneal veins, join with the veins corresponding to the anterior tibial artery, at the lower border of the popliteus, to form the popliteal vein.

Posterior Tibial Nerve. — This is the continuation of the popliteal. It descends close to its corresponding artery, and, behind the inner malleolus, divides into the external and internal plantar nerves. In the first part of its course the nerve lies superficial to the artery, and rather to its inner side; but lower down the nerve crosses the artery, and passes to its outer side, and lies to the inner border of the tendo Achillis. It supplies branches to the three deep-seated muscles, the branch to the flexor longus hallucis accompanying the peroneal artery; and a cutaneous branch — *calcaneo-plantar* — which pierces the internal annular ligament, and supplies the skin of the heel and the inner side of the sole of the foot.

THE DISSECTION OF THE SOLE OF THE FOOT.

Surface-Marking. — The skin of the sole is remarkably thick, especially over the os calcis and the heads of the metatarsal bones. The sole of the foot is convex, and narrow behind, but gradually increases in breadth forwards to the clefts of the toes. The inner arch of the foot, extending from the inner tuberosity of the os calcis to the distal end of the first metatarsal bone, is well marked in a well-developed foot; along this arch can be distinguished the sustentaculum tali; about an inch (*2.5 cm.*) in front of this is the prominent tubercle of the scaphoid, and another inch (*2.5 cm.*) in front of this we can feel the articulation between the internal cuneiform and the base of the metatarsal bone of the great toe. The outer arch of the

foot is neither so deep nor so long as the inner; it extends from the external tubercle of the os calcis to the base of the metatarsal bone of the little toe, and along it we can recognize the peroneal tubercle of the os calcis and the base of the fifth metatarsal bone. The transverse arch, between the heads of the metatarsal bones, is not well marked through the skin, for it is obscured by the tense plantar fascia. The plantar fascia can be made tense by extending the foot, when its narrowest part is seen to be about one inch (*2.5 cm.*) in front of the os calcis. The course of the external plantar artery is indicated by a line drawn from the internal tubercle of the os calcis to the base of the fifth metatarsal bone; that of the internal plantar artery by a line drawn from the same tuberosity to the first interosseous space.

Dissection. — The foot should be firmly fixed to a block with the sole directed towards the dissector, and the toes either fastened by string or nailed to the block, so as to put the plantar fascia on the stretch. Make a perpendicular incision down the middle of the sole; another transverse one across the foot at the clefts of the toes, and continue the perpendicular incision along the middle of the toes to their terminations. Reflect the skin, and notice the peculiar structure of the subcutaneous tissue. It is composed of globular masses of fat, separated by strong fibrous septa, and forms elastic pads, especially marked at the heel, and at the ball of the great and the little toes, these being the points which form the tripod supporting the arch of the foot.

In removing the subcutaneous tissue from the ball of the great and the little toes, we often meet with bursæ, simple or multilocular. They are generally placed between the skin and the sesamoid bones, and have remarkably thick walls. Frequently an artery and nerve can be traced running directly through one of these sacs, which explains the acute pain produced by their inflammation.

Cutaneous Nerves. — In the fat the student must make out the *cutaneous branch* of the posterior tibial nerve, which supplies the skin of the sole of the foot and the heel; the remainder of the sole is supplied by small branches of the plantar nerves which come through the fascia, as in the palm of the hand.

Plantar Fascia.— This is a remarkably dense white and glistening fascia. It extends from the under and back part of

the os calcis to the distal extremities of the metatarsal bones. It is divided into a strong central and two lateral less dense portions, from which prolongations pass deeply inwards, separating the lateral from the central muscles. The *middle portion*, covering the flexor brevis digitorum, is narrow behind, and, as it passes forwards towards the toes, is spread out, and strengthened by transverse fibrous bands. The *inner portion* is comparatively thin, and surrounds the abductor hallucis, becoming continuous posteriorly with the internal annular ligament. The *outer portion* is thicker than the inner, especially as it passes forwards to be attached to the proximal end of the fifth metatarsal bone. It covers the abductor minimi digiti. Both the inner and the outer portions are continuous with the fascia of the dorsum of the foot round the inner and outer borders of the foot, and with the central portion of the plantar fascia towards the centre of the sole.

Near the distal ends of the metatarsal bones, the central part divides into five portions: each of these subdivides into two slips, which embrace the corresponding flexor tendons, and are attached to the metatarsal bones and their connecting ligaments. Between the primary divisions of the fascia — that is, in a line between the toes — are seen the digital vessels and nerves. This arrangement is in all respects like that in the palm.

In the interdigital folds of the skin there are also ligamentous fibres, which run from one side of the foot to the other, and answer the same purpose as those in the hand (p. 357).

The plantar fascia must be partially removed to examine the muscles. Towards the os calcis its removal is not accomplished without some difficulty, since the muscles arise from it.

Superficial Muscles. — After the removal of the fascia three muscles are exposed. All arise from the os calcis and the fascia, and proceed forwards to the toes.* The central one is the flexor brevis digitorum, the one on the inner side is the abductor hallucis, and the outer one is the abductor minimi digiti.

Abductor Hallucis. —This muscle *arises* (Fig. 255) from the internal tubercle of the os calcis, from the plantar fascia,

* They are separated from each other by strong partitions — intermuscular septa — which pass in from the plantar fascia.

from the internal annular ligament, and from the intermuscular septum between it and the flexor brevis digitorum. Its origin arches over the plantar vessels and nerves in their passage to the sole. The fibres run along the inner side of the sole, and terminate on a tendon, which is *inserted* with the inner tendon of the flexor brevis hallucis into the inner side of the base of the first phalanx of the great toe, through the medium of the internal sesamoid bone. Its *nerve* comes from the internal plantar.

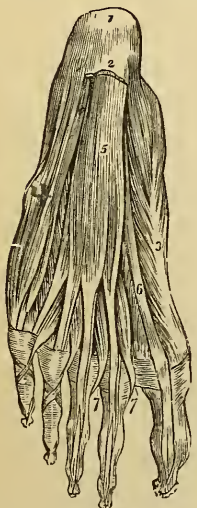


FIG. 255. — SUPERFICIAL MUSCLES OF THE SOLE OF THE FOOT.
1. Calcaneum. 2. Divided plantar fascia. 3. Abductor hallucis. 4. Abductor mimimi digiti. 5. Flexor brevis digitorum. 6. Tendon of the flexor longus hallucis. 7, 7. Tendons of the lumbricales. On the second and third toes, the tendons of the flexor longus digitorum are seen passing through the bifurcation of the tendons of the flexor brevis digitorum.

Abductor Minimi Digiti. — This muscle lies on the outer border of the foot, and has a very strong *origin* from the under surface of the os calcis, from its external tubercle, from the plantar fascia, and from the external intermuscular septum between it and the flexor brevis digitorum. Some of its fibres terminate on a tendon which is *inserted* into the proximal end of the metatarsal bone of the little toe; but the greater part run on to a tendon which is *inserted*, with the flexor brevis minimi digiti, into the outer side of the first phalanx of the little toe. It is *supplied* by the external plantar nerve.

Flexor Brevis Digitorum. — This muscle *arises* from the under surface of the os calcis, between the two preceding, from the deep surface of the plantar fascia and the intermuscular septa. It passes forwards and divides into four tendons, which run superficial to those of the long flexor. Cut open the sheath which contains them; follow them on to the toes, to see that each bifurcates over the first phalanx, to allow the long tendon to pass through; then the two slips, reuniting, are inserted into the sides of the second phalanx. The same arrangement prevails in the fingers. It is *supplied* by the internal plantar nerve.

The three superficial muscles should now be reflected by sawing off about half an inch (*13 mm.*) of the os calcis, and then

turning it downwards with the muscles attached to it. This done, we bring into view the plantar vessels and nerves, and the second layer of muscles, *i.e.*, the long flexor tendon of the great toe, that of the other toes, and the flexor accessorius.

Tendon of the Flexor Longus Digitorum. — Musculus Accessorius. — Tracing this tendon into the sole, you find that an accessory muscle is attached to it. The *flexor accessorius arises* by muscular fibres from the inner concave side of the os calcis and the calcaneo-scaphoid ligament, and by tendinous fibres from the outer side in front of the external tubercle, and from the long plantar ligament. Its fibres run straight forwards, and are *inserted* into the fibular side of the upper surface of the tendon, so that their action is not only to assist in bending the toes, but to make the common tendon pull in a straight line towards the heel, which, from its oblique direction, it could not do without the accessory muscle. The common tendon then divides into four, one for each of the four outer toes. These run in the same sheath with the short tendons, and, after passing through their divisions, are inserted into the bases of the ungual phalanges. Respecting the manner in which the tendons are confined by fibrous sheaths, and lubricated by a synovial lining, what was said of the fingers (p. 364) applies equally to the toes. The flexor accessorius is *supplied* by the external plantar nerve.

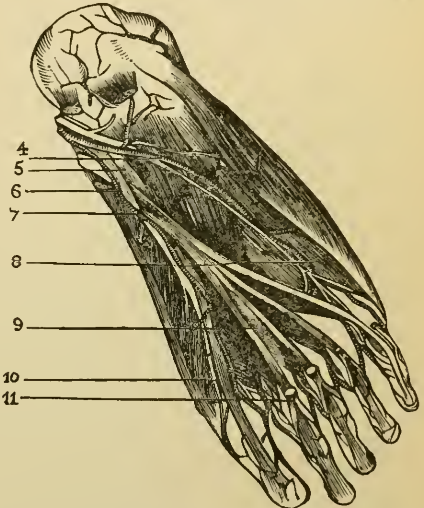


FIG. 256. — MUSCLES, VESSELS, AND NERVES OF THE SOLE OF THE RIGHT FOOT, AFTER REFLECTION OF THE FLEXOR BREVIS DIGITORUM.

1. Abductor minimi digiti. 2. Flexor Accessorius. 3. Abductor hallucis. 4. External plantar artery and nerve. 5. Tendon of flexor longus hallucis. 6, 7. Internal plantar artery and nerve. 8. Flexor brevis minimi digiti. 9. Lumbricales. 10. Internal plantar nerve. 11. Tendons of the flexor brevis digitorum bifurcating for the passage of the tendons of the flexor longus digitorum.

Lumbricales. — These four little muscles are placed between the long flexor tendons. Each, excepting the most internal, which is attached only to the inner side of the tendon going to the second toe, *arises* from the adjacent sides of two tendons,

proceeds forwards, and then, sinking between the toes, terminates in an aponeurosis which passes round the inner side of the four outer toes, and *joins* the extensor tendon on the dorsum of the first phalanges of the toes. Concerning their use, refer to p. 365. The two outer lumbricales are supplied by the external, the two inner by the internal plantar nerve.

Now trace the long fluxor tendon of the great toe. From the groove in the astragalus it runs along the groove in the lesser tuberosity of the os calcis, above, that is nearer to the bones than the tendon of the flexor longus digitorum, between the two heads of the flexor brevis hallucis, and then straight to the base of the last phalanx. It crosses the long flexor tendon of the toes, and the two tendons are connected by an oblique slip, so that we cannot bend the other toes without the great toe.

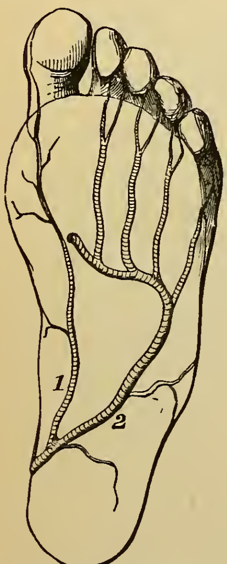


Fig. 257.
1. Internal plantar artery.
2. External plantar artery.

Plantar Arteries. — The posterior tibia artery, having entered the sole between the origins of the abductor hallucis, divides into the external and internal plantar arteries (Fig. 256).

The *internal plantar artery* is smaller than the external plantar artery; it passes forwards between the abductor hallucis and the flexor brevis digitorum to the base of the great toe, and then is continued along the inner side of that toe, where it terminates in small inosculations with the digital arteries. Its chief use is to supply the muscles between which it runs.

The *external plantar* is the principal artery of the sole, and alone forms the plantar arch (Figs. 256 and 257). It runs obliquely outwards across the sole towards the base of the fifth metatarsal bone, then, sinking deeply, it bends inwards across the bases of the metatarsal bones, and inosculates with the communicating branch of the dorsalis pedis in the first interosseous space. At first it lies between the os calcis and the abductor hallucis; it then passes between the flexor brevis digitorum and the flexor accessorius; still continuing its course forwards, it is placed between the flexor brevis digitorum and the flexor brevis minimi digiti, covered only with skin, fat, and plan-

tar fascia, and, lastly, it lies deep beneath the flexor tendons, the lumbricales, the adductor hallucis, upon the interossei muscles. Deeply seated as it appears to be, that part of its curve near the fifth metatarsal bone lies immediately beneath the fascia.

The external plantar sends two or three *internal calcanean* branches to the skin of the heel — one round the outer edge of the foot, which anastomoses with the tarsal and metatarsal branches of the anterior dorsalis pedis, and also some cutaneous branches which emerge between the adjacent borders of the flexor brevis minimi digiti and the flexor brevis digitorum. It also gives off: —

The *digital arteries*, four in number, which arise from the deepest part of the arch. They supply both sides of the fifth, fourth, third, and the outer side of the second toes, and, running forwards along the interossei, divide at the clefts of the toes into two branches, which supply the contiguous side of the adjacent toes. At the point of division the digital arteries send upwards through the front part of the three outer interosseous spaces, small branches, *anterior perforating*, which anastomose on the dorsum of the foot with the interosseous arteries.

The *posterior perforating* are three branches which perforate the back part of the three outer interosseous spaces, and inosculate with the dorsal interosseous arteries at each end of the spaces.

The *digital artery*, supplying the inner side of the great toe and the adjacent sides of the great and second toes, comes from the communicating branch of the dorsal artery of the foot which pierces the back of the first interosseous space to get to the sole of the foot. It is joined here by a branch from the external plantar artery.

Plantar Nerves. — The posterior tibial nerve divides, like the artery, into an external and internal plantar (Fig. 256).

The *internal plantar nerve* is the larger, and runs with its corresponding artery along the inner side of the foot between the abductor hallucis and the flexor brevis digitorum; in this part of its course it distributes *cutaneous branches* to supply the skin of the sole, *muscular branches* to the two above-named muscles, and *articular branches* to the joints of the tarsus and metatarsus.

It then gives off *four digital branches* which supply the three inner toes and a half, like the median in the palm; the *first* digital branch runs along the inner side of the great toe to its tip, and in its passage gives off a branch to the flexor brevis hallucis; the *second* divides into two branches, one of which supplies the inner lumbricalis, and the other the contiguous borders of the great and second toes; the *third* sends a filament to the second lumbrical, and then bifurcates for the supply of the adjacent sides of the second and third toes; the *fourth*, after receiving a communicating filament from the external plantar nerve, is distributed to the contiguous sides of the third and fourth toes. These digital nerves send off small branches to supply the dorsum of the toes at the last phalanges.

The *external plantar nerve* passes obliquely forwards and outwards with the artery of the same name, passing between the flexor accessorius and the flexor brevis digitorum, to the former of which it sends a muscular branch; it then runs along the

inner border of the abductor minimi digiti, supplies it, and then divides into two branches, a superficial and a deep.

The *superficial branch* sends one *digital branch* which supplies the flexor brevis minimi digiti, the plantar and dorsal interossei of the fourth space, and the outer side of the little toe; and another and larger *digital branch* which supplies the contiguous sides of the fourth and fifth nerves, and sends a communicating filament to the outer digital branch of the internal plantar nerve.

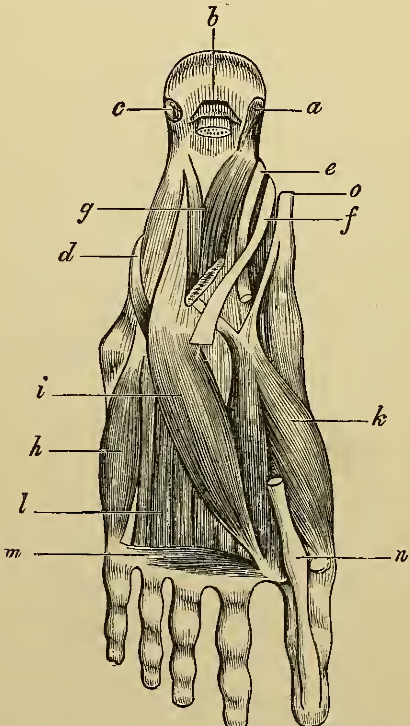


FIG. 258. — VIEW OF THE THIRD LAYER OF MUSCLES OF THE FOOT.

a. Abductor hallucis. *b*. Flexor brevis digitorum. *c*. Abductor minimi digiti. *d*. Tendon of peroneus longus. *e*, *n*. Flexor longus hallucis. *f*. Tendon of flexor longus digitorum. *g*. Flexus accessorius. *h*. Flexor brevis minimi digiti. *i*. Adductor hallucis. *k*. Flexor brevis hallucis. *l*. Interossei. *m*. Transversalis pedis. *o*. Tibialis posticus.

The *deep branch* accompanies the plantar arch deep into the sole of the foot, beneath the adductor hallucis, and furnishes branches to the plantar and dorsal interossei of all the interosseous spaces except the fourth, the adductor hallucis, the transversalis pedis, and the two outer lumbricales.

Third Layer of Muscles. — Having traced the principal vessels and nerves, divide them with the flexor tendons near the os calcis, and turn them down towards the toes, to expose

the deep muscles in the sole. These are, the flexor brevis and adductor hallucis, the flexor brevis minimi digiti, and the transversalis pedis.

Flexor Brevis Hallucis. — This muscle *arises* by a pointed tendon from the cuboid bone, and from the fibrous prolongation of the tibialis posticus into the external cuneiform. It proceeds along the metatarsal bone of the great toe, and divides into two portions, which run one on each side of the long flexor tendon, and are inserted by tendons into the sides of the first phalanx of the great toe. The inner tendon is inseparably connected with the abductor hallucis, the outer with the adductor hallucis. In each tendon there is a sesamoid bone. These bones not only increase the strength of the muscle, but, both together, form a pulley for the free play of the long flexor tendon, so that in walking the tendon is not pressed upon. Its *nerve* comes from the internal plantar (Fig. 258, *k*).

Adductor Hallucis. — This very powerful muscle *arises* from the bases of the second, third, and fourth metatarsal bones, and from the sheath of the peroneus longus. Passing obliquely forwards and inwards across the foot, it is *inserted* through the external sesamoid bone into the outer side of the base of the first phalanx of the great toe together with the inner head of the flexor brevis. This muscle greatly contributes to support the arch of the foot. Like the adductor of the thumb, it should be considered as an interosseous muscle. Its *nerve* is derived from the external plantar (Fig. 258, *i*).

Flexor Brevis Minimi Digiti. — This little muscle rests on the fifth metatarsal bone, and *arises* from the base of the fifth metatarsal bone and the sheath of the peroneus longus ; it proceeds forwards along the bone, and is *inserted* into the outer side of the base of the first phalanx of the little toe. It is *supplied* by the external plantar nerve (Fig. 258, *h*).

Transversalis Pedis. — This slender muscle runs transversely across the distal ends of the metatarsal bones. It *arises* by little fleshy slips from the inferior metatarso-phalangeal ligaments of the three outer toes and the transverse ligament of the metatarsus, and is *inserted* into the outer side of the first phalanx of the great toe with the adductor hallucis, of which it ought to be considered a part. Its *nerve* comes from the external plantar (Fig. 258 *m*).

The fourth layer of muscles consists of the *interossei.*

Interossei. — These muscles are arranged nearly like those

in the hand. They occupy the intervals between the metatarsal bones, and are seven in number, four being on the dorsal aspect of the foot, three on the plantar. The four *dorsal interossei arise* each by two heads from the contiguous sides of the metatarsal bones, and are *inserted* into the bases of the first phalanges, and into the aponeurosis of the extensor communis digitorum on the dorsum of the toes. The first is inserted into the inner side of the second toe; the remaining three into the outer side of the second, third, and fourth. The *plantar interossei,* three in number, *arise* from the inner sides and under surfaces of the third, fourth, and fifth metatarsal bones, and are *inserted* respectively into the inner sides of the bases of the first phalanges of the third, fourth, and fifth toes, and into the aponeurosis of the common extensor tendon.

The use of the interosseous muscles is to draw the toes to or from each other, and they do the one or the other according to the side of the phalanx on which they act. Now, if we draw a longitudinal line through the second toe, we find that all the dorsal muscles draw *from* that line, and the plantar *towards* it. This is the key to the action of them all. A more detailed account of these muscles is given in the dissection of the hand (p. 398). Between the tendons of the interossei — that is, between the distal ends of the metatarsal bones, there are bursæ which facilitate movement. They sometimes becomes enlarged and occasion painful swellings between the roots of the toes. The flexor brevis minimi digiti, the transversalis pedis, and all the interossei, are supplied by the *external plantar nerve.*

Now trace the tendons of the peroneus longus and tibialis posticus. The *tendon* of the *peroneus longus* is the deepest in the sole. It runs through a groove in the cuboid bone obliquely across the sole towards its insertion into the outer side of the base of the metatarsal bone of the great toe and into the internal cuneiform bone; not infrequently it has a fasciculus of attachment into the second metatarsal bone. It is confined in a strong fibrous sheath, lined throughout by synovial membrane.

The *tendon* of the *tibialis posticus* may be traced over the internal lateral ligament of the ankle, and thence under the head of the astragalus to the tuberosity of the scaphoid, and the internal cuneiform bones. Prolongations are sent off to the cuneiform bones, to the cuboid, to the sustentaculum tali, and to the bases of the second, third, and fourth metatarsal bones. Observe that the tendon contributes to support the

head of the astragalus, and that for this purpose it often contains a sesamoid bone. This is one of the many provisions for the maintenance of the arch of the foot.

DISSECTION OF THE LIGAMENTS.

Ligaments of the Pelvis with the Fifth Lumbar Vertebra. — The sacrum is united to the last lumbar vertebra in the same manner as one vertebra is to another, viz., by the prolongation of the anterior and posterior common ligaments, the intervertebral fibro-cartilage, the ligamenta subflava, supra- and interspinous ligaments, and the capsular ligaments. The student should, therefore, refer to the description of the ligaments of the spine (p. 296).

The *ilio-lumbar ligament* is very strong, and extends directly outwards from the tip of the transverse process of the last lumbar vertebra to the crest of the ilium (Fig. 259).

Ligaments of the Sacrum and Coccyx. — The *lumbo-sacral ligament* varies much in its extent and attachment, and passes from the anterior and lower border of the transverse process of the fifth lumbar vertebra to the lateral part of the base of the sacrum; the fibres as they descend obliquely outwards become frayed out, joining in part the anterior sacro-iliac ligament. The sacrum is connected with the coccyx by means of an anterior and a posterior sacro-coccygeal ligament and by an intervertebral fibro-cartilage.

The *posterior sacro-coccygeal ligament* is a flattened fasciculus of fibres extending from the lower margin of the sacral canal to the posterior surface of the coccyx; this ligament closes in the inferior termination of the sacral canal.

The *anterior sacro-coccygeal ligament* is a thin band of fibres passing along the front of the sacrum to the coccyx.

The *intervertebral disk* is a thin layer of fibro-cartilage, firm in the centre, thinner laterally and in front and behind, with occasionally a synovial membrane. Laterally, there are some irregular strands of fibres, the *lateral ligaments*, which extend from the lower lateral part of the sacrum to the transverse process of the coccyx.

The segments of the coccyx are in early life separated by interposed fibro-cartilages, which subsequently ossify; they have in front and behind a continuation of the *anterior* and *posterior common ligaments*.

The innominate bones are connected to each other in front, constituting the *symphysis pubis;* posteriorly, to the sacrum, forming the *sacro-iliac symphysis.*

Sacro-iliac Articulation. — This articulation is an example of that form of amphiarthrodial joints where the surfaces are covered with fibro-cartilage, with an incomplete synovial membrane. The articulation is formed between the auricular surfaces of the lateral portions of the sacrum and ilium. The anterior part of the bones forming this articulation is incrusted with articular cartilage, of which the shape is like that of the ear. Later in life these two surfaces are more or less connected by thin interarticular transverse fibres, so that the interval between them is very irregular, and frequently contains yellow, viscid material. In front of the articulation there is the anterior sacro-iliac ligament, and behind, the posterior sacro-iliac ligament.

The *anterior sacro-iliac ligament* consists of thin ligamentous fibres passing in front of the sacrum and ilium (Fig. 259).

The *posterior sacro-iliac ligament* (Fig. 260) is composed of fibres much stronger and more marked, which pass behind the articulation. It consists of two portions: the upper, or *horizontal,* extends from the upper two transverse tubercles of the sacrum, and is attached to the rough surface of the ilium above the auricular surface; the lower, or oblique, is a well-marked fasciculus of fibres, the *oblique sacro-iliac ligament,* passing from the posterior superior spine to the third segment of the sacrum.

Sacro-sciatic Ligaments. — These are two strong ligaments passing from the sacrum to the ischium.

The *great sacro-sciatic ligament* (Fig. 260, 2) is triangular and thick, but narrower in the middle than at either extremity. Its base is broad, and is *attached* to the posterior inferior iliac spine, and to the sides of the sacrum and coccyx; rapidly narrowing, it descends obliquely outwards towards the tuberosity of the ischium, where it again expands to be *attached* to the inner margin of this bone. This attached portion is continued upwards for some distance as a prolongation, the *falciform process,* into the inner margin of the ramus of the ischium, where it becomes continuous with the obturator fascia, forming a protection for the pudic vessels and nerve (*Alcock's Canal*).

The *lesser sacro-sciatic ligament* (Fig. 260, 3) lies in front of the preceding ligament, and, like it, is triangular, though smaller and shorter. It *passes* from the sides of the sacrum and

coccyx to the spine of the ischium, where it narrows considerably. The attachments of the sacro-sciatic ligaments to the sacrum and coccyx are more or less blended, and they not only serve to connect the bones, but also, from their great breadth, contribute to diminish the lower aperture of the pelvis.

Pubic Symphysis. — This is formed by the union of the pubic bones, in front, by means of an interposed piece of fibro-

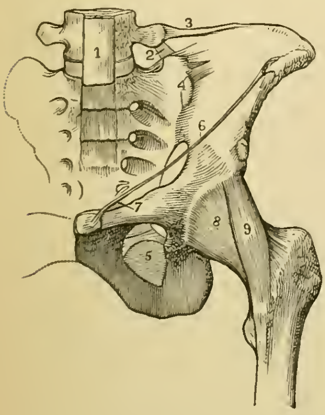


Fig. 259. — Ligaments of the Pelvis and Hip-Joint.

1. Lower part of the anterior common ligament of the vertebræ, extending downwards over the front of the sacrum. 2. Lumbo-sacral ligament. 3. Lumbo-iliac ligament. 4. Anterior sacro-iliac ligament. 5. Obturator membrane. 6. Poupart's ligament. 7. Gimbernat's ligament. 8. Capsular ligament of the hip-joint. 9. Ilio-femoral or accessory ligament.

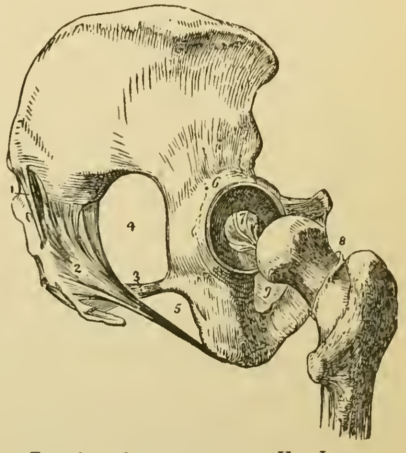


Fig. 260. — Ligaments of the Hip-Joint. (Lateral view.)

1. Oblique sacro-iliac. The other portions of this ligament are not seen in this view. 2. Posterior sacro-sciatic (greater). 3. Anterior sacro-sciatic (lesser). 4. Great sacro-sciatic foramen. 5. Lesser sacro-sciatic foramen. 6. Cotyloid ligament. 7. Ligamentum teres. 8. Divided capsular ligament. 9. Obturator membrane only partly seen.

cartilage. It is an amphiarthrodial articulation, and is secured by the following ligaments: —

The *anterior pubic ligament* consists of several layers of irregular superficial fibres which run obliquely and decussate with each other, and of deeper fibres which pass transversely across from one bone to the other, and are connected with the fibro-cartilage.

The *posterior pubic ligament* consists of fibres, less distinct than the anterior, which connect the two pubic bones posteriorly.

The *superior pubic ligament* passes across the upper surface of the pubic bones.

The *subpubic ligament* is very strong, and extends between the rami of the pubic bones, beneath the fibro-cartilage with which it is blended; it rounds off the pubic arch, and is situated between the two layers of the triangular ligament.

The *intermediate fibro-cartilage* is composed of two layers of cartilage, each attached to the inner border of the body of the os pubis by a number of nipple-like processes fitting into corresponding depressions on the bony surface. Between these cartilaginous plates there is a thick stratum of fibrous and fibro-elastic tissue. In the middle line at the upper and back part is usually a smooth cavity lined with epithelium. The cartilage acts as a buffer, and breaks the force of shocks passing through the pelvic arch.*

Ligaments of the Hip-joint. — This joint is secured by the form of the bones, and by the strength of the powerful muscles which surround it. Although an enarthrodial or ball-and-socket joint, its range of motion is somewhat limited; the disposition of its ligaments restricts its range of motion to those directions only which are most consistent with the maintenance of the erect attitude and the requirements of this part of the skeleton.

The ligaments of the hip-joint are — the capsular, the ilio-femoral,† the ligamentum teres, the cotyloid, and the transverse.

Capsula Ligament. — The *capsular ligament* (Fig. 259, 8) is *attached* above to the circumference of the acetabulum, a little external to the margin, also to the transverse ligament, and by a few fibres to the outer margin of the obturator foramen; below, to the anterior intertrochanteric ridge in front; above, to the root of the great trochanter, and to the middle of the neck behind, about half an inch (*13 mm.*) above the posterior intertrochanteric ridge. The anterior and upper part of the capsular ligament is very thick and strong, composed chiefly of longitudinal fibres with a few deeply seated circular fibres, which are concealed by the superficial longitudinal bands. The

* It must be remembered that ordinarily there is no motion in this joint, but that pregnancy occasionally causes a laxity in this joint which when marked causes great pain while walking. As this joint is now subjected to section in malformed pelvis or abnormality in the child, advantage may be taken of this relaxed condition in the operation. (A. H.)

† The pecteno-femoral and ischio-femoral are thickened portions of the capsule attached to the parts indicated by their names.

posterior aspect of the capsular ligament is represented by a few sparsely scattered fibres. The front part of the ligament is rendered exceeding strong by several accessory ligaments, one of which, called the *ilio-femoral ligament*, extends from the anterior inferior iliac spine, and from a depression above the acetabulum, and then divides like the two arms of the inverted letter λ; one, the inner and vertical, passes to the base of the lesser trochanteric; the outer, to the upper part of the anterior intertrochanteric line. In addition, there is at the lower and back part a broad ligament, the *ischio-capsular ligament*, whose fibres extend from the ischium to the inner part of the joint, close to the lesser trochanter; and a third accessory ligament, the *pubo-femoral*, consists of the thin fibres converging from the ilio-pectineal eminence, and the margin of the obturator foramen to the front and inner part of the capsular ligament.

The ilio-femoral ligament is very strong, and serves as a strap to prevent the femur being extended beyond a certain point, and limits rotation inwards and outwards. (This ligament is sometimes called the Y-shaped ligament of Bigelow.)

The capsule is in relation, in front, with the iliacus and psoas muscles, from which it is separated by a synovial bursa. This bursa occasionally communicates by a rounded aperture with the synovial capacity of the hip-joint.

Open the capsule to ascertain its great thickness in front and its strong attachment to the bones. This exposes the cotyloid ligament and the ligamentum teres.

Ligamentum Teres. — The *ligamentum teres* is exposed by drawing the head of the femur out of the socket. This ligament is somewhat flat and triangular. Its base, which is bifid, is attached below to the borders of the notch in the acetabulum, where it becomes continuous with the transverse ligament; its apex, to the fossa in the head of the femur. To prevent pressure on it, and to allow free room for its play, there is a gap at the bottom of the acetabulum. This gap is not crusted with cartilage like the rest of the socket, but is occupied by soft fat. The ligamentum teres is surrounded by the synovial membrane. An artery runs up with it to the head of the femur. It is a branch of the obturator, and enters the acetabulum through the notch at the lower part.

The chief use of the ligamentum teres is to assist in steadying the pelvis on the thigh in the erect position. In this position the ligament is vertical and quite tight (Fig. 261); it therefore

prevents the pelvis from rolling towards the opposite side, or the thigh from being adducted beyond a certain point.

Cotyloid Ligament. — The *cotyloid ligament* is an annular piece of fibro-cartilage which is attached all round the margin of the acetabulum. Its circumference is thicker than its free margin, which is very thin, so that on a transverse section the cartilage is triangular. Both its surfaces are covered with synovial membrane, and its attachment to the margin of the

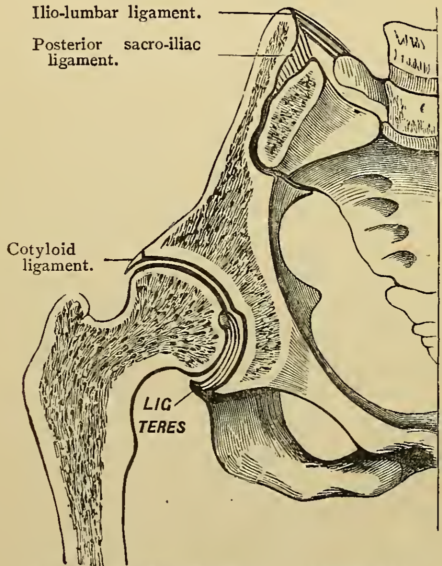


FIG. 261. — VERTICLE SECTION THROUGH THE HIP.

acetabulum is effected by oblique fibres passing from without inwards, and interlacing in all directions at an acute angle. The ligament is thicker above and behind than elsewhere; it thus deepens the socket, and embraces the head of the femur like a sucker. It extends over the notch at the lower part of the acetabulum, being attached to a ligament, the *transverse*, which passes across the notch, and thus converts it into a foramen.

Transverse Ligament. — Beneath the transverse ligament some of the vessels and nerves pass into the joint to supply it.

Synovial Membrane. — The *synovial membrane* extends from the cartilaginous border of the head, round the neck as

far as the attachment of the capsular ligament, on the inner surface of which it is reflected as far as the margin of the acetabulum. Thence it passes over the superficial surface of the cotyloid ligament, curves round its inner sharp border so as to line its deeper surface; it then covers the osseous surface of the acetabulum, and is finally continued as a tubular sheath over the ligamentum teres to the head of the femur. The synovial membrane, it will be seen, extends down to the base of the neck of the femur in *front*, but only two-thirds *behind*. Between the bottom of the acetabulum, as far as the cotyloid notch and the synovial membrane, is a collection of fat and connective tissue called the *gland of Havers*.

The ligaments of the hip-joint are so arranged that when we stand "at ease" the pelvis is spontaneously thrown into a position in which its range of motion is the most restricted; for the accessory ligaments of the capsule prevent it from being extended beyond a straight line, and the ligamentum teres prevents its rolling towards the opposite side. This arrangement economizes muscular force in balancing the trunk.

The atmospheric pressure is, of itself, sufficient to keep the limb suspended from the pelvis, supposing all muscles and ligaments to be divided. When fluid is effused into the hip-joint the bones are no longer maintained in accurate contact; and it sometimes happens that the head of the femur escapes from its cavity, giving rise to a spontaneous dislocation.

The *movements at the hip-joint* are those of flexion, extension, abduction, adduction, rotation, and circumduction.

The *flexors* are, the ilio-psoas, the sartorius, the pectineus, the adductor longus and brevis, the gluteus medius, and minimus.

The *extensors* are, the gluteus maximus, the biceps, semitendinous, and the semimembranosus.

The *abductors* are, the upper fibres of the gluteus maximus, the gluteus medius and minimus, the pyriformis, and when the joint is flexed, the obturator internus and the two gemelli.

The *adductors* are, the three adductors, the pectineus, the gracilis, and the sartorius.

The *external rotators* are, the three adductors, the pectineus, the gluteus maximus, the posterior fibres of the gluteus medius, the obturator externus and internus, the gemelli, the quadratus femoris, the pyriformis, and the sartorius.

The *internal rotators* are, the ilio-psoas occasionly,* the tensor fasciæ femoris, the anterior fibres of the gluteus medius, and the gluteus minimus.

Circumduction is effected by the successive action of the different muscles in the order of their attachment into the femur.

The muscles in immediate relation with the hip-joint are, in front, the iliacus and psoas; on the outer side, the reflected tendon of the rectus, the gluteus minimus; behind, the pyriformis, gemellus superior, obturator internus, gemellus inferior, obturator externus, and quadratus femorus; on the inner side, the pectineus and obturator externus.

Ligaments of the Knee-joint. — The knee-joint is a ginglymus or a hinge-joint, and the bones entering into its formation are, above, the condyles of the femur, below, the head of the tibia, and in front, the patella. Looking at the skeleton, one would suppose that it was very insecure; but this insecurity is only apparent, the joint being surrounded by powerful ligaments, and a thick capsule formed by the tendons of the muscles which act upon it.

First examine the tendons concerned in the protection of the knee-joint. In front is the ligamentum patellæ; on each side are the tendons of the vasti; on the other side, in addition, it is strengthened by the strong ilio-tibial band; on the inner side there are also the tendons of the sartorius and gracilis; at the back of the joint are the tendons of the gastronemius and plantaris, with the semimembranosus and semitendinosus, in addition, on its inner part, and the tendons of the popliteus and biceps on its outer part. It deserves to be mentioned that the weakest part of the articulation is near the tendon of the popliteus, which arises *within* the joint; here, therefore, pus or fluid formed in the popliteal space may make its way into the joint, or *vice versâ*.

The ligaments of the joint may be divided into those outside the joint and those within it.

Those *outside* the joint are, the ligamentum patellæ, the internal lateral, the two external lateral, the posterior ligament, and the capsular ligament.

Those *within* the joint are, the two crucial, the two semi-

* Although the ilio-psoas has been formerly classified as an external rotator, it can be readily demonstrated to be just the reverse. Attention has been called to this point in Morris' Anatomy, Amer. Ed., p. 366. See action of individual muscles, present work. (A. H.)

lunar fibro-cartilages, the transverse, the coronary, the ligamenta alaria, and the ligamentum mucosum.

Ligamentum Patellæ.—The *ligamentum patellæ* is a strong, thick, ligamentous band, about three inches (*7.5 cm.*) long, extending from the lower border of the patella to the tubercle of the tibia. Beneath is found a considerable amount of fat, which separates the ligament from the joint, and in fat people forms a prominent elastic mass on each side of the ligament. There is a synovial bursa between the ligamentum patellæ and the tuberosity of the tibia.*

Internal Lateral Ligament.—This is a broad, flat band, which extends from the inner condyle of the femur to the inner tuberosity and the inner aspect of the shaft of the tiba (Fig. 262). A few of the fibres are attached to the inner semilunar cartilage, and serve to keep it in place. The inferior internal articular artery, and part of the tendon of the semimembranosus, pass underneath this ligament. In the several motions of the joint there is a certain amount of friction between the ligament and the head of the tibia, and consequently a small bursa is interposed.

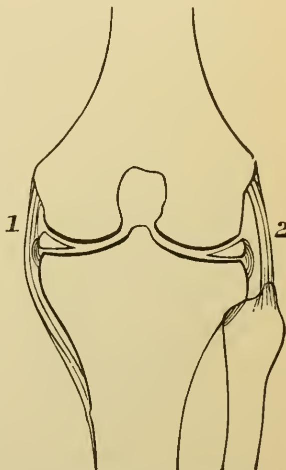


FIG. 262.—DIAGRAM OF THE SEMILUNAR CARTILAGES AND LATERAL LIGAMENTS OF THE KNEE.

1. Internal lateral ligament. 2. External lateral ligament.

External Lateral Ligaments.—The *long external lateral ligament* is a strong round band which extends from the outer condyle of the femur to the outer part of the head of the fibula. This ligament separates the two divisions of the tendinous insertion of the biceps. Beneath it pass the tendon of the popliteus and the inferior external articular artery.

The *short external lateral ligament* is situated posterior to, and runs parallel with the preceding ligament; it passes from the posterior and outer part of the condyle of the femur to the tip of the styloid process of the fibula; the tendon of the popliteus also lies beneath it.

* There are two oblique projections of ligamentous tissue from the sides of the patella extending to the head of the tibia. These are parts of the extensor tendon and act as accessories to the patellar ligament (Morris's Anat., Amer. Ed., p. 271). (A. H.)

Posterior Ligament. — This, which is generally called the *ligamentum posticum Winslowii* (Fig. 263), covers the whole of the posterior surface of the knee-joint, and consists of two portions — one formed by a broad flat band of vertical fibres passing from the posterior surface of the femur between and above the condyles, to the posterior part of the tuberosity of the tibia; the other consists of an oblique tendinous expansion from the semimembranosus (p. 659), which passes upwards and outwards from the internal tuberosity of the tibia to the back of the outer condyle of the femur. It is pierced by numerous blood-vessels to supply the knee-joint, chiefly by the azygos

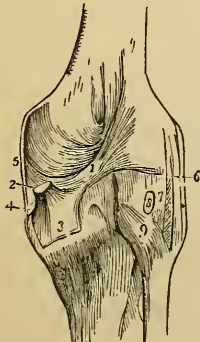


FIG. 263. — POSTERIOR VIEW OF THE LIGAMENTS OF THE KNEE-JOINT.

1. Oblique portion of the posterior ligament (Winslow's). 2. Tendon of the semimembranosus m. cut. 3. Process of this tendon which expands into fascia from which gives attachment to the popliteus muscle. 4. Process which passes under the internal lateral ligament. 5. Internal lateral ligament. 6. Long external lateral ligamant. 7. Short external lateral ligament. 8. Tendon; the popliteus cut through. 9. Posterior tibio-fibular ligament.

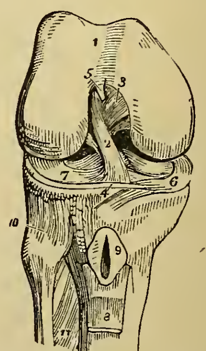


FIG. 264.— INTERNAL LIGAMENTS OF THE KNEE-JOINT (R.).

1. Condyles of the femur; five rest on the external, three rest on the internal condyle. 2. Anterior or external crucial ligament. 3. Posterior or internal crucial ligament. 4. Transverse ligament. 5. Attachment of the ligamentum mucosum, the remainder being removed. 6. Internal semilunar fibro-cartilage. 7. External semilunar fibro-cartilage. 8. Reflected ligamentum patellæ. 9. Sub-patellæ bursa opened. 10. Anterior superior tibio-fibular ligament. 11. Interosseous membrane.

artery and a branch from the obturator nerve (p. 627). This ligament not only closes and protects the joint behind, but prevents its extension beyond the perpendicular.

Capsular Ligament. — The *capisular ligament* occupies the intervals between the other ligaments, and so completes the fibrous investment of the joint. It is materially strengthened by fibrous expansions from many of the tendons in connection with the articulation.

The joint should be opened above the patella. Observe the great extent of the fold which the synovial membrane forms above this bone.* It allows the free play of the bone over the lower part of the femur. The fold extends higher above the inner than the outer condyle, which accounts for the form of swelling produced by effusion into the joint.

Crucial Ligaments. — The *crucial ligaments*, so named because they cross like the letter X, extend from the mesial side of each condyle to the head of the tibia.

The *anterior* or *external ligament* (Fig. 264, 2), the smaller, ascends from the inner part of the fossa in front of the spine of the tibia, backwards and outwards to the inner and back part of the external condyle. It is attached to the tibia close to the anterior termination of the external semilunar cartilage.

The *posterior* or *internal ligament* (3), best seen from behind, extends from the back of the fossa behind the spine of the tibia, and from the posterior termination of the external semilunar cartilage, upwards, forwards, and inwards to the front of the inner condyle. The direction of this ligament is more vertical, but is stronger and shorter than the former.

Interarticular or Semilunar Fibro-cartilages. — Between the condyles and the articular surfaces of the tibia are two incomplete rings of fibro-cartilage (Fig. 264, 6, 7), shaped like the letter C. They serve to deepen the articular surfaces of the tibia; their mobility and flexibility enable them to adapt themselves to the condyles in the several movements of the joint; they distribute pressure over a greater surface and break shocks. They are thickest at the circumference, and gradually shelve off to a thin margin; thus they fit in between the bones, and adapt a convex surface to a flat one, as shown in Fig. 262. Their form is suited to the condyles, the inner being oval, the outer circular, and the synovial membrane covers both surfaces of the cartilages.

The *external semilunar fibro-cartilage* is nearly a circular ring of fibro-cartilage, its two extremities being firmly attached to the fossæ, one in front of and the other behind the spine of the tibia; they are enclosed by the two extremities of the internal cartilage.

On its outer border it presents a groove for the tendon of the popliteus; its anterior border gives off a transverse fibrous

* In performing operations near the knee, the joint should always be bent, in order to draw the synovial fold as much as possible out of the way.

fasciculus, the transverse ligament (Fig. 264, 4), which passes across to be connected with the anterior border of the internal cartilage. The anterior extremity of the fibro-cartilage is connected with the anterior crucial ligament; the posterior is attached partly into the outer side of the inner tuberosity in front and behind the posterior crucial ligament, and partly into the anterior crucial ligament.*

The *internal semilunar fibro-cartilage* (6) forms about two-thirds of an oval ring, and is narrower in front than behind. Its anterior extremity is pointed, and is attached to the tibia internal to the anterior crucial ligament; its posterior extremity to the pit behind the spine immediately in front of the posterior crucial ligament.

The *transverse ligament* (4), already alluded to, is a thin fibrous fosciculus in front of the anterior crucial ligament, and connects the anterior borders of the semilunar fibro-cartilages.

The *coronary ligaments* are two ligaments which connect the circumference of the two semiluner cartilages to the borders of the tibial tuberosities. The external ligament is the weaker of the two, so that the external cartilage is the more movable.

Synovial Membrane.—The synovial membrane is very extensive, the most extensive in the body. It lines the posterior surface of the quadriceps tendon, and the aponeuroses of the vasti, and is reflected on to the femur a variable distance above the incrusting cartilage; traced from the femur, we find that it lines the inner surface of the capsular ligament as far as the circumference of the tibia; thence it is reflected over the upper surfaces of the semilunar cartilages, round their inner concave margins to get to their under surfaces, from which the membrane passes to cover the articular surface of the head of the tibia. It forms tubular prolongations round the crucial ligaments, and below the patella a slender band of the synovial membrane proceeds backwards to the space between the condyles, and is called the *ligamentum mucosum*. Two lateral folds, extending from the sides of the mucous ligament, pass upwards and outwards to the sides of the patella; these are

* Of the two cartilages the external has the greater freedom of motion, because in rotation of the knee the outer side of the tibia moves more than the inner. Consequently, it is not in any way connected to the external lateral ligament; so far from this, it is separated from it by the tendon of the popliteus, of which the play is facilitated by a bursa communicating freely with the joint. For this reason the external cartilage is more liable to dislocation than the internal.

termed the *ligamenta alaria*. These are not true ligaments, but merely remnants of the partition which, in the early stage of the joint's growth, divided it into two equal portions.

Outside the synovial membrane there is always fat, especially under the ligamentum patellæ. Its use is to fill up vacuities, and to mould itself to the several movements of the joint.

The movements which the knee-joint permits are those of flexion and extension, together with rotation outwards and inwards. In order completely to master its various movements, the student should examine the movements first as between the femur and the patella, and then as between the condyles of the femur and the articular surface of the tibia crowned by its two semilunar cartilages.

The articular surface of the patella glides upon the femoral condyles in extension and in flexion. If this surface of the patella be examined, it will be seen that each lateral facet is subdivided by two indistinct transverse ridges into three very shallow transverse zones; each of these zones rests upon a definite part of the trochlear surface of the femur in the different stages of extension or flexion; thus, in extreme extension, the lower zones of the patella rest upon the upper border of the trochlear surface; in mid-flexion, the middle zones alone rest on the femur; and in nearly extreme flexion, the upper zones lie on the lower part of the femoral condyles. In addition to the six shallow facets just described, there is a seventh, which is seen on the inner margin.

The respective points of the attachment of the ligaments are such that, when the joint is extended, all the ligaments are tight, to prevent extension beyond the perpendicular; thus muscular force is economized. But when the joint is bent the ligaments are relaxed enough to admit a slight rotatory movement of the tibia.

This movement is more free outwards than inwards, and is effected, not by rotation of the tibia on its own axis, but by rotation of the outer head round the inner. Rotation outwards is produced by the biceps; rotation inwards by the popliteus and semimembranosus.

The crucial ligaments, though placed inside the joint, answer the same purposes as the coronoid process and the olecranon of the elbow. They make the tibia *slide* properly forwards and backwards. In extension, the anterior crucial ligament is tight,

as are also the lateral ligaments; in flexion, the posterior ligament becomes tight, and consequently limits flexion. They also conjointly limit excessive rotation. They not only prevent dislocation in front or behind, but they prevent lateral displacement, since they cross each other like braces, as shown in Fig. 265.

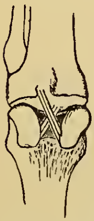


FIG. 265.—CRUCIAL LIGAMENTS OF THE KNEE.

Superior Tibio-fibular Articulation.—This is an arthrodial or gliding joint, and is formed by the flat oval surfaces of the upper part of the tibia and fibula. It is secured by an anterior and a posterior tibio-fibular ligament.

The *anterior superior tibio-fibular ligament* is a strong flat ligament whose fibres pass obliquely downwards and outwards from the external tuberosity of the tibia to the head of the fibula.

The *posterior superior ligament* passes in the same direction as the anterior, only being placed behind the joint.*

The *synovial membrane* occasionally communicates with that of the knee-joint.

Interosseous Membrane. — The contiguous borders of the tibia and fibula are connected by the interosseus membrane. The purpose of it is to afford additional surface for the attachment of muscles. Its fibres pass chiefly downwards and outwards from the tibia to the fibula, but a few fibres cross like the letter X. The anterior tibial artery comes forwards above the interosseous membrane through an oval space about an inch (*2.5 cm.*) below the head of the fibula. Lower down there is an aperture for the anterior peroneal artery. It is, moreover, pierced here and there by small blood-vessels.

Inferior Tibio-fibular Articulation. — The lower extremities of the tibia and fibula are firmly connected, for it is essential to the security of the ankle-joint that there should be little or no movement between the two bones.

The *anterior inferior ligament* passes between the adjacent borders of the two bones; it is narrow above but broader below, and consists of oblique fibres which pass downwards and outwards.

The *posterior inferior ligament* is stronger and narrower than

* A capsular ligament is described by many authors attached close to the articular margins of the tibia and fibula, extending a little behind and below the margin of the latter. (A. H.)

the anterior, and its fibres pass horizontally from the outer malleolus to the posterior border of the tibia, above the articular surface.

The *tranverse ligament* is the lower part of the preceding, and may be usually recognized as a distinct narrow fasciculus.

The *inferior interosseous ligament* consists of strong short fibres connecting the contiguous surfaces of the two bones, and continuous above with the interosseous membrane.

The *synovial membrane* of this joint is an extension upwards of that of the ankle-joint.*

Ankle-joint. — From the form of the bones, it is obvious that the angle is a ginglymus or hinge-joint; consequently, its security depends upon the great strength of its *lateral ligaments*. The hinge, however, is not so perfect but that it admits of a slight rotatory motion, of which the centre is on the fibular side, and therefore the reverse of that in the case of the knee.

The ligaments of the ankle-joint comprise the anterior, the posterior, the internal, and the external lateral ligaments.

The *anterior ligament* is a thin loose membranous ligament, attached above to the articular portion of the tibia, and below to the astragalus in front of its articular surface, and is sufficiently loose to permit the necessary range of motion.

The *posterior ligament* is a thin disconnected membranous ligament, attached above to the posterior inferior tibio-fibular ligament, to the external malleolus internal to the peroneal groove; and below to the posterior surface of the astragalus from the internal to the external ligaments of the ankle-joint.

The *internal lateral ligament*, sometimes called, from its shape, *deltoid*, is exceedingly thick and strong, and compensates for the comparative shortness of the internal malleolus (Fig. 266). The great strength of it is proved by the fact that, in dislocation of the ankle inwards, the summit of the malleolus is more often broken off than the ligament is torn. The *superficial portion* of this ligament is attached above to the margin of the internal malleolus, and passing downwards radiates to be inserted into the scaphoid, the inner side of the astragalus, the sustentaculum tali, and the inferior calcaneo-scaphoid ligament; the *deeper portion*, thick and strong, passes from the tip of the malleolus to the astragalus, close to its articular border.

The *external lateral ligament* consists of three distinct fas-

* The movement is one of gliding very limited upwards and downwards. (A. H.)

ciculi — an anterior, a posterior, and a middle (Fig. 267). The *anterior fasciculus* passes from the front of the tip of the exter-

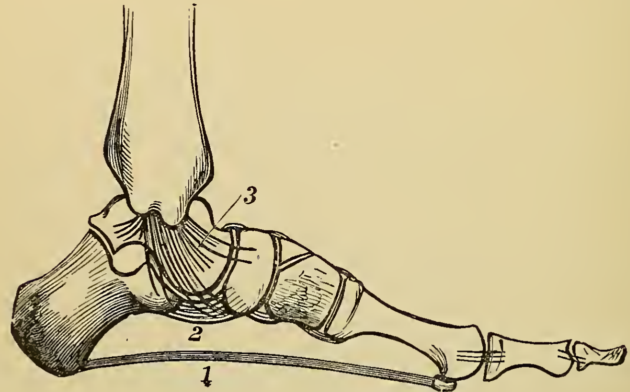


FIG. 266.

1. Plantar fascia. 2. Calcaneo-scaphoid ligament which supports the head of the astragalus. 3. Internal lateral ligament, called from its shape deltoid.

nal malleolus, nearly horizontally forwards and inwards to the astragalus in front of its malleolar articular surface. The *middle fasciculus*, round and long, passes obliquely downwards and backwards to the outer surface of the os calcis. The *posterior fasciculus* passes from the posterior part of the external malleolus, nearly horizontally outwards, to the back of the astragalus below its upper articular surface.

FIG. 267.—DIAGRAM OF THE EXTERNAL LATERAL LIGAMENT.

1. Anterior part. 2. Posterior part. 3. Middle part. 4. Interosseous ligament between the astragalus and os calcis.

Besides flexion and extension, the ankle-joint admits of a slight lateral movement, only permitted in the extended state, for the better direction of our steps. In adaptation to this movement the internal malleolus is shorter than the outer; it is not so tightly confined by its ligaments, and its articular surface is part of a cylinder.

Open the joint to see that the breadth of the articular surfaces of the bones is greater in front than behind. The object of this is to render the astra-

galus less liable to be dislocated backwards. Whenever this happens, the astragalus must of necessity become firmly locked between the malleoli.

Ligaments connecting the Bones of the Tarsus.—The astragalus is the keystone of the arch of the foot, and supports the whole weight of the body. It articulates with the os calcis and the os scaphoides in such a manner as to permit the abduction and adduction of the foot, so useful in the direction of our steps.

Astragalo-calcanean Ligaments.—The astragalus articulates with the os calcis by two surfaces separated by the deep interosseous groove, of which the posterior is concave, and the anterior convex. The articulations are strengthened by four ligaments, the external, the internal, and the posterior astragalo-calcanean, and the interosseous.

The *external astragalo-calcanean ligament* is a short, quadrilateral fasciculus, passing from the outer surface of the astragalus, in front of the anterior fasciculus of the external lateral ligament, almost directly downwards to the outer surface of the os calcis.

The Internal Calcaneo-astragaloid ligament is a band of fibres passing between the posterior portion of the astragalus and the sustentaculum tali. Its fibres closely blend with the fibres of the inferior calcaneo-scaphoid ligament.

The *posterior astragalo-calcanean ligament* is a short oblique band, which passes from the posterior border of the astragalus to the upper border of the os calcis.

The *interosseous ligament* is a very thick strong band of fibres which descends vertically into the interosseous canal, and is the principal band of union between the two bones.

Astragalo-scaphoid Ligament.—The anterior surface of the astragalus is broadly convex, fitting into the concave surface of the scaphoid bone. Superiorly the dorsal surfaces of the two bones are connected by a broad membranous ligament, *astragalo-scaphoid,* which passes obliquely across, blending externally with the external calcaneo-scaphoid, and below with the inferior calcaneo-scaphoid ligament.

Calcaneo-scaphoid Ligaments.—In the skeleton the head of the astragalus articulates in front with the scaphoid, but the lower part of it is unsupported. This interval is bridged over by a very strong and slightly elastic ligament, which extends from the os calcis to the scaphoid (Fig. 268); this is the inferior calcaneo-scaphoid ligament.

The *inferior calcaneo-scaphoid ligament* is thick and strong, and passes horizontally forwards and inwards from the sustentaculum tali to the plantar surface of the scaphoid, where it is connected with the tendon of the tibialis posticus, and, superiorly, with the astragalo-scaphoid ligament. Thus the os calcis, scaphoid, and this ligament form a complete socket for

FIG. 268.
1. Calcaneo-scaphoid ligament. 2. Calcaneo-cuboid ligament.

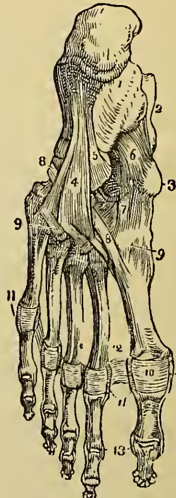


FIG. 269.—LIGAMENTS OF THE SOLE OF THE FOOT.
1. Os calcis. 2. Astragalus. 3. Tuberosity of the scaphoid. 4. Long calcaneo-cuboid lig. 5. Part of the short calcaneo-cuboid lig. 6. Calcaneo-scaphoid lig. 7. Plantar tarsal ligament. 8, 8. Tendon of the peroneus longus m. 9, 9. Plantar tarso-metatarsal lig. 10. Metatarso-phalangeal lig. 11, 11, 11. Lateral metatarso-phalangeal. 12. Transverse. 13. Lateral of the phalanges of the great toe.

the head of the astragalus ; it is this joint, chiefly, which permits the abduction and adduction of the foot. In chronic disease of the ankle-joint, leading to much impairment of movement at this joint, the motion at the astragalo-scaphoid articulation is so great as to take the place of the ankle-joint. This ligament being slightly elastic, allows the keystone of the arch (the astragalus) a play, which is of great service in preventing concussion of the body. Whenever this ligament yields, the head of the astragalus falls, and the individual becomes gradually flat-footed. In this yielding of the ligament the head of the astragalus not only falls, but becomes also rotated inwards.

The *superior calcaneo-scaphoid ligament* is short and triangular, lying in the hollow between the outer part of the astragalus and the os calcis; it passes forwards and upwards from the ridge on the anterior and outer part of the os calcis to the outer side of the scaphoid.

Calcaneo-cuboid Articulation. — The os calcis articulates with the os cuboides nearly on a line with the joint between the astragalus and the scaphoid. The bones are connected together, on the dorsum, by the superior and internal calcaneo-cuboid ligaments, and on the plantar aspect by the long and short calcaneo-cuboid ligaments.

The *superior calcaneo-cuboid ligament* is a short quadrilateral band of fibres passing from the upper part of the dorsal aspect of the os calcis to the back and upper part of the os cuboides.

The *internal calcaneo-cuboid ligament* connects the front part of the ridge of the os calcis to the dorsal and inner part of the cuboid. It is sometimes called the *interosseous ligament*, and is closely associated with the superior calcaneo-scaphoid ligament.

The *long calcaneo-cuboid ligament* (Fig. 269), a broad, long, and strong band of ligamentous fibres, is the more superficial of the two inferior calcaneo-cuboid ligaments. It is known as the *long plantar ligament*, and is attached to the under surface of the os calcis in front of the tuberosities, as far as the anterior tubercle; it passes forward to the plantar aspect of the cuboid, being attached to the ridge, while some of its fibres extend to the bases of the second, third, and fourth metatarsal bones, and complete the canal for the tendon of the peroneus longus.

The *short calcaneo-cuboid ligament* (short plantar) deeper than the former, is seen somewhat on its inner aspect, and is separated from it by some fat and connective tissue. It is very broad, and passes from the front of the tubercle of the os calcis, for about an inch in breadth, to the inner and posterior surface of the cuboid, behind the ridge.

The articulations between the cuboid and the scaphoid bones behind, and the three cuneiform bones in front, are maintained by dorsal, plantar, and interosseous ligaments.

The *dorsal* and the *plantar ligaments* consist of parallel fasciculi passing between the contiguous borders of the respective bones on their dorsal and plantar aspects.

The *interosseus ligaments*, three in number, are composed of

transverse fibres (Fig. 270) connecting the rough non-articular surfaces of the contiguous bones; the first one is between the scaphoid and the cuboid; the second connects the internal and middle cuneiform bones; the third is between the middle and external cuneiform bones; and the fourth between the external cuneiform and the cuboid bones.

Fig. 270. — Interosseous Ligaments of the Wedge-bones.

Though there is very little motion between any two bones, the collective amount is such that the foot is enabled to adapt itself accurately to the ground; pressure is more equally distributed, and consequently there is a firmer basis for the support of the body. Being composed, moreover, of several pieces, each of which possesses a certain elasticity, the foot gains a general springiness and strength which could not have resulted from a single bone.

Tarso-metatarsal Joints. — The tarsus articulates with the metatarsus in an oblique line which inclines backwards on its outward side. This line is interrupted at the joint of the middle cuneiform bone and the second metatarsal bone. Here there is a deep recess, so that the base of this metatarsal bone is wedged in between the internal and external cuneiform bones.

These joints are maintained in position, above, by the dorsal tarso-metatarsal ligaments, and, below, by the plantar ligaments. Interosseous ligaments also pass between the wedge-bones, maintaining them in their normal positions.

Synovial Membranes of the Tarsus. — Exclusive of the ankle-joint and the phalanges of the toes, the bones of the foot are provided with six distinct synovial membranes, namely —

1. Between the posterior articular surface of the os calcis and that of the astragalus.
2. Between the head of the astragalus and the scaphoid, and between the anterior articular surface of the astragalus and os calcis.
3. Between the os calcis and the os cuboides.
4. Between the inner cuneiform bone and the metatarsal bone of the great toe.
5. Between the scaphoid and the three cuneiform bones, and between these and the adjoining bones (the great toe excepted).
6. Between the os cuboides and the fourth and fifth metatarsal bones.

The tarso-metatarsal articulations are arthrodial joints.

Inter-metatarsal Articulation. — The metatarsal bones are connected at their proximal and distal ends by *dorsal* and *plantar ligaments;* those at the proximal extremities are very strong, and are supplemented by interosseous ligaments, as in the metacarpus (p. 414). The movement between the proximal ends of the inter-metarsal articulations is arthroidal or gliding.

The distal extremities of the metatarsal bones are united by a *transverse metatarsal ligament;* this extends from the great toe to the little toe on their plantar surfaces.

FIG. 271. — DIAGRAM OF THE ARTICULATIONS OF THE TARSUS AND THE TARSO-METATARSUS.

1. Posterior calcaneo-astragaloid synovial cavity. 2. Calcaneo-scaphoid synovial cavity. 3. Calcaneo-cuboid synovial cavity. 4. Synovial cavity between metatarsal bone of great toe and internal cuneiform bone. 5. Common scapho-cuneiform, intercuneiform, and metatarso-cuneiform synovial cavity. 6. Cubo-metatarsal synovial cavity.

Metatarso-phalangeal Articulations. — These are connected by a *plantar* and *two lateral ligaments*; the dorsal ligament being formed by the expansion of the tendon of the extensor longus digitorum. The movements which take place between the articulations are those of flexion, extension, abduction, and adduction.

Phalangeal Articulations. — These articulations have the same kind of ligaments as the preceding, and the movements are also nearly identical.

DISSECTION OF THE BRAIN.

Membranes of the Brain. — Before passing on to the examination of the brain, the student should study the arrangement, the structure, and the uses of the three membranes by which the brain is enveloped.

The most external one, the *dura*, has been described (p. 26). The second, or intermediate one, is a serous membrane, termed the *arachnoid;* the third, the *pia*, is a vascular layer, and is in contact with the encephalon.

Arachnoid Membrane. — The *arachnoid membrane*, the second investment, constitutes the smooth polished membrane covering the surface of the brain, and is exposed after the removal of the dura. This tunic was formerly considered by anatomists to be an example of an ordinary serous membrane, and was described as consisting of two layers — an external or parietal, which lined the inner surface of the dura, and an internal or visceral, which was reflected over the brain. It is nów regarded as consisting of one layer only, viz., the one which envelops the brain ; the under aspect of the dura being covered only with a layer of flattened epithelium cells. The cavity which was formerly described as the cavity of the arachnoid, is now called the *subdural space*, and contains a very limited amount of fluid.

The arachnoid membrane is a colorless and transparent layer, and is spread uniformly over the surface of the brain, from which it is separated by the pia. It does not, like the pia, dip down into the furrows between the convolutions of the brain, and it is more or less connected with the pia by delicate connective tissue, the *subarachnoid.* On account of its extreme tenuity, and its close adhesion to the pia, the two membranes cannot be readily separated ; but there are places, especially at the base of the brain, termed *subarachnoid spaces*, where the arachnoid membrane can be seen distinct from the subjacent pia. The two membranes can be artificially separated by blowing air beneath the arachnoid with a blow-pipe.

Subarachnoid Spaces and Fluid. — Wherever the arachnoid membrane is separated from the pia, a serous fluid (*cerebro-*

spinal) intervenes, contained in the meshes of a very delicate areolar tissue. The spaces between these membranes are termed *subarachnoid*, and are very manifest in some places. For instance, there is one well-marked space in the longitudinal fissure, where the arachnoid does not descend to the bottom, but passes across the edge of the falx, a little above the callosum. At the base of the brain there are two of considerable size: one, the *anterior subarachnoid space*, or cysterna, is situated between the anterior border of the pons, the tempero-sphenoidal, and the frontal cerebral lobes; the other, the *posterior subarachnoid space*, cysterna pontis, is placed between the cerebellar hemispheres and the medulla oblongata. The fluid in the subarachnoid space communicates with the fluid of the general ventricular cavities of the brain through an aperture (*foramen of Magendie*) in the fourth ventricle, close to its lower boundary; and also through an opening, on each side, behind the glosso-pharyngeal nerves. In the spinal cord, also, there is a considerable interval containing fluid between the arachnoid and the pia. The purpose of this fluid is, not only to fill up space, as fat does in other parts, but mechanically to protect the nerve-centres from the violent shocks and vibrations to which they would otherwise be liable.

The brain, therefore, may be said to be supported in a fluid, which insinuates itself into all the inequalities of the surface, and surrounds in fluid sheaths all the nerves as far as the foramina through which they pass. This fluid sometimes escapes through the ear, in cases of fracture through the base of the skull involving the meatus auditorious internus and the petrous portion of the temporal bone.

The arachnoid is supplied with filaments from the motor root of the fifth, the facial, and the spinal accessory nerves.

The *cerebro-spinal fluid* varies in amount from two drachms to two ounces (*7.3 c.cm. to 59 c.cm.*). It is a clear, limpid fluid, slightly alkaline, containing 98.5 parts of water, and 1.5 parts of solid matter. The cerebro spinal fluid of the encephalon and that of the spinal cord communicate.

Pia. — This, the immediate investing membrane of the brain, is extremely vascular, and composed of a minute network of blood-vessels held together by delicate connective tissue. It covers the cerebral surface, and dips into the fissures between the convolutions, forming a double layer. From its internal surface numerous vessels pass off at right angles into the sub-

stance of the brain.* The pia sends a prolongation through the transverse fissure into the lateral and third ventricles, forming the *velum interpositum* and the *choroid plexuses*, and also another along the roof of the fourth ventricle, forming the *tela choroidea inferior*. Upon the surface of the cerebellum the pia is thinner, not so vascular, and only sends prolongations down the larger sulci; on the pons and the medulla the membrane is more fibrous and much less vascular than elsewhere.

The pia is supplied with nerves by the third, fifth, sixth, facial, glosso-pharyngeal, pneumogastric, spinal-accessory, and sympathetic nerves, which chiefly accompany the blood-vessels forming the pia mater.

Arteries of the Brain. — The brain is supplied with blood by the two internal carotid and the two vertebral arteries.

Internal Carotid. — This artery enters the skull through the carotid canal in the temporal bone, and ascends very tortuously, by the side of the body of the sphenoid, along the inner wall of the cavernous sinus. It appears on the inner side of the anterior clinoid process, and after giving off the ophthalmic, divides into an anterior and middle cerebral, posterior communicating and anterior choroid arteries.

a. The *anterior cerebral artery* is given off from the internal carotid at the inner end of the fissure of Sylvius. It passes forwards and inwards to reach the longitudinal fissure between the hemispheres, curves round the front part of the callosum, then runs backwards over its upper surface (under the name of the *artery of the callosum*), and terminates in branches which anastomose with the posterior cerebral arteries. The anterior cerebral arteries of opposite sides run side by side, and supply the olfactory lobes, the optic nerves, the frontal lobes, the anterior perforated spaces, or precribria, and the callosum. At the base of the brain, as they enter the longitudinal fissure, they are connected by a short transverse branch, called the *anterior communicating artery* (Fig. 272).

b. The *middle cerebral artery*, the largest branch of the internal carotid, runs outwards deeply within the fissure of Sylvius, and divides into many branches distributed to the frontal and tempero-sphenoidal lobes. Near its origin it gives off a number of small arteries, which pierce the locus perforatus anticus, or precribrium, to supply the striatum.

c. The *posterior communicating artery, unequal in size usually on the two sides, proceeds directly backwards to join the posterior cerebral; thus establishing at the base of the brain the free arterial inosculation called the* CIRCLE OF WILLIS.

d. The *anterior choroid artery*, a small branch of the internal carotid, arises external to the posterior communicating artery. It runs backwards, and enters the fissure at the bottom of the middle horn of the lateral ventricle, to terminate in the choroid plexus of that cavity. It supplies, in addition, the hippocampus major and the corpus fimbriatum.

* Owing to these vessels, the pia, when placed in water, presents a flocculent, woolly appearance, and hence it is sometimes called *tomentum cerebri*.

Vertebral Artery. — This artery, a branch of the subclavian in the first part of its course, enters the foramen in the transverse process of the sixth cervical vertebra, and ascends through the transverse processes of the cervical vertebræ. It then winds backwards along the arch of the atlas, and enters the

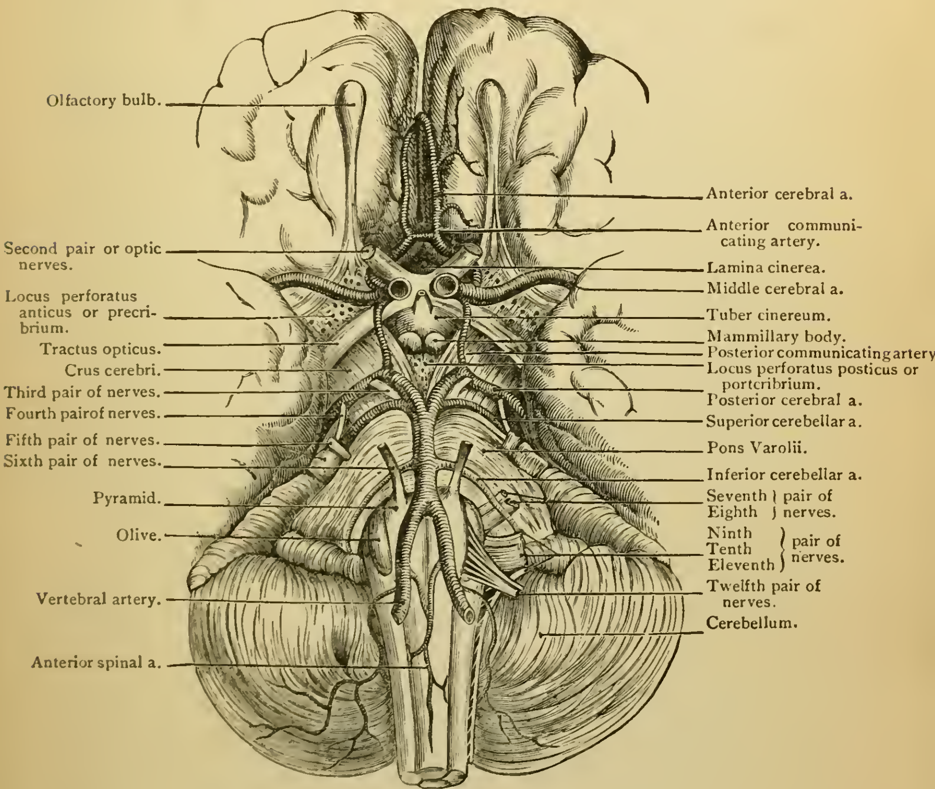


FIG. 272.

skull through the foramen by perforating the posterior occipito-atlantal ligament and the dura. It then curves round the medulla between the hypoglossal nerve and the anterior root of the first cervical nerve. At the lower border of the pons the two arteries unite to form a single trunk — the *basilar* — which is lodged in the groove on the middle of the pons, and bifurcates at its upper border into the posterior cerebral arteries.

Each vertebral artery, before joining its fellow, gives off: —

a. Lateral spinal branches, which enter the spinal canal, to supply the spinal its membranes, and the bodies of the cervical vertebra.

b. Muscular branches to the deep muscles of the neck, which anastomose with the occipital and deep cervical arteries.

c. A *posterior meningeal branch*, distributed to the posterior fossa of the skull.

d. Anterior spinal arteries, which are given off immediately before the vertebral arteries join to form the basilar, run along the median fissures of the ventral and the dorsal surfaces of the spinal cord, and anastomose with the spinal branches of the ascending cervical arteries.

e. The *posterior inferior cerebellar artery*, sometimes a branch of the basilar, but more frequently of the vertebral, passes backwards between the spinal-accessory and the pneumogastric nerves, to the under surface of the cerebellum. It divides into two branches : an outer, which ramifies on the lower surface of the cerebellum as far as its outer border ; and an inner, which passes to the vallecula between the two hemispheres, and supplies branches to the fourth ventricle.

The *basilar artery*, formed by the junction of the two vertebral, in its course along the pons, gives off on each side : —

a. Transverse branches which pass outwards on the pons : one, the *internal auditory*, enters the meatus auditorius internus with the auditory nerve, to be distributed to the internal ear on each side.

b. The *anterior inferior cerebellar*, which supplies the front part of the lower surface of the cerebellum, and anastomoses with the other cerebellar arteries.

c. The *superior cerebellar arteries*, given off near the bifurcation of the basilar, are distributed to the upper surface of the cerebellum, and anastomose with the inferior cerebellar ; branches are supplied to the pineal body, the valve of Vieussens, and the velum interpositum.

d. The *posterior cerebral arteries are the two terminal branches into which the basilar artery divides.* They run outwards and backwards, in front of the third cranial nerve, and wind round the crura cerebri to the under surface of the posterior cerebral lobes, where they divide into numerous branches for the supply of the brain, anastomosing with the anterior and middle cerebral arteries. *Shortly after their origins they receive the two posterior communicating arteries from the internal carotids.* Each gives off small branches to the posterior perforated space or post-cribrium, and also the smal. *posterior choroid artery*, which, passing beneath the posterior border of the callosum and fornix, is distributed to the velum interpositum and choroid plexus.

Circle of Willis. — This important arterial inosculation (Fig. 272) takes place between the branches of the two internal carotid and the two vertebral arteries. It is formed, laterally, by the two anterior cerebral, the two internal carotid, and the two posterior communicating arteries ; in front, it is completed by the anterior communicating artery ; behind, by the two posterior cerebral. The tortuosity of the large arteries before they enter the brain serves to mitigate the force of the heart's action ; and the circle of Willis provides a free supply of blood from other vessels, in case any accidental circumstance should stop the flow of blood through any of the more direct channels.*

* In many of the long-necked herbivorous quadrupeds a provision has been made in the disposition of the internal carotid arteries, for the purpose of equaliz-

Peculiarities of the Cerebral Circulation. — Besides the circle of Willis, there are other peculiarities relating to the circulation of the blood in the brain: namely, the length and tortuosity of the four great arteries as they enter the skull; their passage through tortuous bony canals; the spreading of their ramifications in a very delicate membrane, the pia, before they enter the substance of the brain; the minuteness of the capillaries, and the extreme thinness of their walls; the formation of the venous sinuses (p. 29), which do not accompany the arteries; the chordæ Willisii in the superior longitudinal sinus; the absence of valves in the sinuses; and the confluence of no less than six sinuses, forming the *torcular Herophili*, at the internal occipital protuberance.

General Division of the Brain. — The mass of nervous substance contained within the cranial cavity, comprised under the common term brain (*encephalon*), is divided into four parts. The *cerebrum* forms the largest portion, and occupies the whole of the upper part of the cranial cavity; its base resting on the anterior and middle fossæ and the tentorium cerebelli. It is connected with the pons by two white nerve-masses, the *crura cerebri*, and with the cerebellum by two white cords, the *crura cerebelli*. The *cerebellum*, or smaller brain, occupies the space between the tentorium cerebelli and the occipital fossæ. The *pons* is the quadrilateral mass of white fibres which rests upon the basilar process of the occipital bone. The *medulla oblongata* is the portion below the pons, which is continuous below with the spinal cord and rests upon the lower part of the basilar process of the occipital bone.

The result of a large number of observations shows that the weight of the brain averages in males 49½ oz. (*1374.8 grm.*), and in females about 44 oz. (*1245.2 grm.*); although it has been known to weigh as much as 64 oz. (*1711.2 grm.*), as in the case of Cuvier's brain, and as little as 23 oz. (*655.5 grm.*), in the case of an idiot's brain.

The average specific gravity of the brain is about 1036; that of the white matter being 1040, and that of the gray 1034.

ing the force of the blood supplied to the brain. The arteries, as they enter the skull, divide into several branches, which again unite and form a remarkable network of arteries, called by Galen, who first described it, the '*rete mirabile*.' The object of this evidently is to moderate the rapidity with which the blood would otherwise enter the cranium in the different positions of the head, and thus preserve the brain from those sudden influxions to which it would under other circumstances be continually exposed.

The relative proportion of the amount of white to gray matter is, 64 per cent. of white substance to 36 per cent of gray matter.

The weight of the encephalon varies greatly in different subjects, and although its weight seems to bear some proportionate relation to the intellectual power, yet in many instances there appears to be no such definite relation.

The brain weight gradually increases up to the age of forty, when it attains its maximum ; after this period the weight decreases at the rate of one ounce for every additional ten years of life.

MEDULLA OBLONGATA.

The medulla oblongata, spinal bulb or oblongata, is that part of the cerebro-spinal axis which is placed below the pons, and is continuous with the spinal cord on a level with the upper border of the atlas. It is slightly pyramidal in shape, with the broad part above. It lies on the basilar groove of the occipital bone, and descends obliquely backwards through the foramen magnum. Its posterior or dorsal surface is received into the fossa (valecula) between the hemispheres of the cerebellum. It is about an inch and a quarter (*3.1 cm.*) in length, three-quarters of an inch (*1.8 cm.*) at the broadest part, and half an inch (*3.1 mm.*) in thickness. It has a superior and an inferior extremity, and four surfaces — a ventral, two lateral, and a dorsal. Its superior extremity is directly connected with the dorsal surface of the pons, but the ventral surface is separated by a distinct horizontal groove, from which emerges the sixth, seventh, and eighth cranial nerves. Its inferior extremity is connected with the spinal cord. The ventral surface of the medulla is divided into two equal parts by the ventro-median fissure, in the lower part of which is seen the decussation of the crossed pyramidal tracts. At its upper end the fissure terminates at the pons in a cul-de-sac, termed the *foramen cæcum* of Vic d'Azyr. On each side of this fissure are the *pyramids.*

The pyramids are two columns of white matter, narrow below, but increasing gradually in breadth as they ascend toward the pons, and separated from each other by the ventro-median fissure, and from the corresponding lateral suface by the ventro-lateral fissure. The fibres of the pyramids are divided into a mesial and a lateral tract ; the mesial tract is made up of the decussation of the crossed pyramidal tract already spoken of ;

the lateral fibres are continuous with the fibres lying next to the ventro-median fissure of the cord. All the fibres of the pyramids may be traced through the pons to the crura cerebri.

Each lateral surface is separated from the ventral surface by the ventro-lateral fissure, and from the dorsal surface by the dorso-lateral fissure. At the upper part of this surface on each side is found an oval eminence, called the *olive, or olivary body.* The lower half of this area is occupied by the *lateral tracts.* The *lateral tracts* are composed of the antero-lateral ground bundle, and the antero-lateral ascending and descending cerebellar tracts (Gray). Some of these fibres pass over and some beneath the olivary body, while others pass in the grooves on each side of this body.

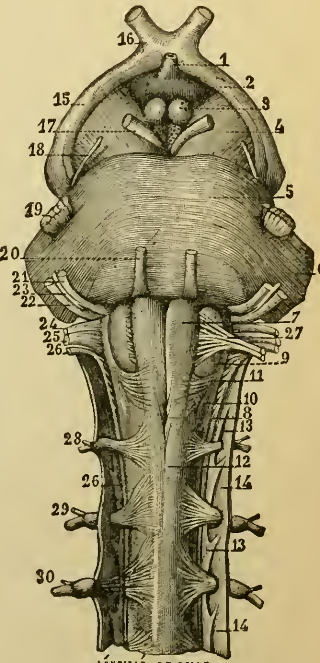


Fig. 273.—Pons and Medulla Ventral Aspect.

The *olivary bodies* are two oval eminences about $\frac{2}{5}$ of an inch (*1 cm.*) long, situated in the upper half of each lateral area. They do not ascend as high as the pons, for there is a deep groove between them. They consist externally of white matter, and at their lower part some white fibres may be observed arching round from the ventro-median fissure, constituting the *arciform fibres of Rolando.* In the fissure between the ventral pyramids and these bodies are seen the fasiculi of the hypoglossal nerve emerging from the medulla, and in the fissure behind the olive emerge the roots of the glosso-pharyngeal, the pneumogastric, and the spinal-accessory nerves. The olivary bodies are composed, as before stated, externally of white matter ; but if a transverse section be made into them, their interior presents an undulating line of yellowish-brown color, called from its zigzag shape, the *corpus dentatum,* or *nucleus of the olivary body.* It forms an interrupted capsule, incomplete at the upper and inner side, so that it allows the entrance of a bundle of white fibres, the *olivary* peduncle, from the medulla behind the pyramid.

These fibres are distributed in various ways; some pass through and join the restiform body under the name of the *internal arcuate fibres*, and some passing between the fibres of the olivary body, come to the surface and curve round it, forming the *external arcuate fibres*. Two other isolated gray nuclei may be recognized in the transverse section, one on the inner side of and the other behind the corpus dentatum; these called the *accessory olivary nuclei* are linear in shape, and about $\frac{1}{12}$ of an inch (*2 mm.*) in length; the root fibres of the hypoglossal nerve pass between the inner nucleus and corpus dentatum to emerge between the pyramid and the olivary body.

The dorsal surface of the medulla in its lower part is divided equally by the dorso-median fissure; on each side is the dorso-median column, or *funiculus gracilis* (column of Goll), whose upper extremity terminates in a prominence called the *clava*. This prominence diverges slightly from its fellow, and forms part of the lower boundary of the fourth ventricle. On the outer side of the funiculus gracilis, and separated from it by the dorso-intermediate fissure, is the *funiculus cuneatus;* this column is the larger of the two, ends at the upper part on the *cuneate tubercle*, which lies just at the outer side of the clava. Separated from the funiculus cuneatus by a slight fissure (the dorso-median) on its outer side is the *funiculus of Rolando*; this column also terminates in an eminence called the *tubercle of Rolando*, just beneath the restiform body. Most external of all the columns on the dorsal surface is the *direct cerebellar tract*. This tract originally belonged to the lateral surface of the spinal cord; but as it reaches the lower part of the medulla, it pushes backward, displacing the dorso-lateral fissure, and passes to the dorsal surface, now being the most external portion of this surface, and continues upward to form the restiform body in conjunction with the internal arciform fibres.

The upper half of the dorsal half of the medulla is that portion of the bulb which enters into the formation of the floor of the fourth ventricle, and will be described later. This portion is separated from the cerebellum by a membrane composed of the ventral layer of endyma and a dorsal layer of pia stretched across between the dorsal pyramid, or funiculus gracilis. This being a place where the nervous tissue of the encephalic wall has disappeared and left only its lining and vascular membranes, which coming in contact here, form the *posterior medullary ve-*

lum, or *metatela*. From its ventral surface hang blood vessels covered by endyma, called the choroid plexuses of the fourth ventricle. In the middle of this membrane is a perforation, the foramen of Magendie or metapore, by means of which the cerebro-spinal fluid mingles with that surrounding the spinal axis. The obex is a thickened portion of the endyma attached to the lower angle of the fourth ventricle; and the ligula, a thin lamina of white substance which connects the endyma with the lateral angle of the fourth ventricle.

On the lower part of the upper half is seen the *restiform bodies* or restis. The *restiform bodies* are two rounded cords made up of the direct or inferior cerebellar tracts and the internal arciform fibres; as before stated, they begin at the lower part of the upper half of the dorsal surface, and pass outward, upward and backward to the cerebellum, forming the inferior peduncles of that body.

PONS VAROLII.

The *pons* (bridge) *Varolii*, or *pons tuber annulare*, is the convex eminence of transverse white fibres (Fig. 273) which is situated at the base of the brain immediately above the medulla oblongata. It rests upon the basilar groove of the occipital and the sphenoid bones. Its *upper margin* is convex and well defined, and arches over the crura cerebri; the *lower*, also well defined, is nearly straight, being separated from the medulla by a transverse groove. *Laterally*, the pons becomes narrower, in consequence of its transverse fibres being more closely aggregated; these enter the anterior and under part of the cerebellum, constituting its *middle peduncle*. Along the middle runs a shallow groove, broader above than below, which lodges the basilar artery. If the pia be removed, we observe how the superficial fibres pass transversely to connect the two hemispheres of the cerebellum. Throughout the mammalia the size of the pons bears a direct ratio to the degree of development of the lateral lobes of the cerebellum; therefore it is larger in man than in any other animal.*

The pons consists of four layers of alternating transverse and

* Birds, reptiles, and fishes have no pons, as there are no lateral lobes to the cerebellum.

longitudinal white fibres, intermingled with more or less gray matter, which is chiefly found on its upper surface, where it forms part of the floor of the fourth ventricle.

The *superficial layer* of white fibres is transverse, connecting the cerebellar hemispheres; the middle fibres pass transversely across, the inferior ascend slightly, while the superior pass backwards and outwards to enter the cerebellum.

The *second layer* consists of longitudinal fibres which are the continuation of the fibres of the medulla oblongata in their passage to the cerebrum. It is mainly composed of fibres derived from the pyramids which pass up to form the superficial fibres, *crusta*, of the crura cerebri.

The *third layer* is formed of transverse fibres, which, from their peculiar arrangement take the name of *trapezium ;* the fibres in their course outwards pass round in front of the superior olivary nuclei, then across the fasciculi of the facial nerves, and lastly in front of the ascending roots of the fifth nerves to enter the middle peduncle of the cerebellum.

The *deepest* and *uppermost layer* is composed of longitudinal nerve-fibres; those derived from the olivary fasciculi divide into two bundles, one ascending to the corpora quadrigemina, the other passing to the cerebrum; and those derived from the lateral and posterior columns of the cord, which, with a fasciculus from the fillet, form the fasciculi teretes in the floor of the fourth ventricle, and pass upwards to form the *tegmenta*, or deeper portions of the crura cerebri.

The gray matter is chiefly aggregated at the posterior part of the pons, and varies in thickness in different sections. Thus a section through the middle of the pons will show the following nuclei of gray matter, beginning from the central groove and passing outwards: a small intermediate portion of the facial nerve, the large nucleus of the sixth, the facial nerve, the large superior nucleus of the auditory nerve; while below we notice the superior olivary nucleus, the nucleus of the facial nerve, and externally the gray substance of Rolando, enclosing the ascending root of the fifth nerve.

The pons, like the medulla oblongata, has an imperfect median septum composed of horizontal fibres, some of which, at the anterior border, surround the crura cerebri.

THE CEREBRUM.

The *cerebrum* in man is so much more developed than the other parts of the encephalon that it completely overlies them, and forms by far the largest portion. It is oval in form and convex on its external aspect. It is divided in the middle line into two symmetrical parts, termed the *right* and *left hemispheres*, by the deep *longitudinal fissure*, which is occupied by the falx (p. 28).* The cerebrum is composed of numerous

* Examples are occasionally met with where the longitudinal fissure is not exactly in the middle line, the consequence of which want of symmetry is, that one hemisphere is larger than the other. Bichat (*Recherches physiologiques sur la Vie et la Mort*, Paris, 1829) was of opinion that this anomaly exercised a deleterious influence on the intellect. It was remarkable that the examination of his own brain after death went to prove the error of his theory.

parts — viz., of certain internal ganglionic masses, the corpora striata, optic thalami, and corpora quadrigemina; of commissural white fibres, the fornix, callosum, and the commissures of the third ventricle; of the pineal and pituitary bodies; and, lastly, of the two lateral hemispheres, which overlie and conceal the parts previously mentioned.

The cerebrum rests upon the anterior and middle fossæ of the base of the skull, and the tentorium cerebelli. There are three surfaces to each hemisphere: an *external* or convex; an *inner* or median; and an *inferior*, interrupted by the fissure of Sylvius.

By widely separating the two hemispheres at the longitudinal fissure (the brain being in its natural position), we discover that they are connected in the middle by the transverse white commissure, called the *callosum*. In front of, and behind this mass, the longitudinal fissure extends to the base of the brain.

The cerebral hemispheres, viewed from above, form an ovoid mass, broader in front than behind, and convex to correspond with the vault of the calvaria. Their surface is mapped out by tortuous eminences termed *convolutions* (*gyri*), separated from each other by deep furrows (*sulci*), which extend to a variable depth. Many of the sulci are occupied by large veins in their course to the sinuses; others are filled with a subarachnoid fluid. The convolutions are folds of the brain, and their outer surface consists of gray matter, so that the extent of the gray substance is thus very largely increased; the gray matter here is called the *cortical substance*. The interior of the convolutions consists of white nerve substance. The convolutions are not symmetrical on both sides, although they follow a somewhat similar arrangement. The number, arrangement, and depth of the convolutions vary somewhat in different individuals, and, to a certain extent, may be considered an index to the degree of intelligence.*

The depth of the sulci between the convolutions varies in different brains, from an inch to half an inch (*2.5 cm. to 13 mm.*); hence it follows that two brains of equal size may be very

* Those who wish to investigate the cerebral convolutions in their simplest form in the lower classes of mammalia, and to trace them through their successive development and arrangement into groups as we ascend to the higher classes, should consult Leuret, *Anatomie comparée du Système Nerveux considérée dans ses Rapports avec l'Intelligence*, Paris, 1839; also Foville, *Traité de l'Anat. du Système Nerveux, etc.*, Paris, 1844. The convolutions of the human brain have been described by Ecker, *On the Convolutions of the Human Brain*, 1873; and by Turner, *The Convolutions of the Human Brain topographically considered*, Edin., 1866; *Proceedings Amer. Ass. Anatomists*, Wilder, Spt., 1900.

unequal in point of extent of surface for the gray matter, and therefore in amount of intellectual capacity. Under the microscope the cortical layer is seen to consist of four layers — two of gray alternating with two of white — the external layer being always white. These layers are not equally thick in all situations, and in some parts six layers may be demonstrated, owing to the interpolation of a layer of white substance in the outer stratum: these are chiefly seen near the callosum and in the occipital lobe.*

Fig. 274 (A). — View of the Convolutions and Fissures of the External Surface of the Brain (Left Side).

A. Fissure of Rolando. B. Fissure of Sylvius. C. Inter-parietal fissure. P.O. Parieto-occipital fissure. *c.m.* Calloso-marginal fissure. F. Frontal lobe. P. Parietal lobe. O. Occipital lobe. T.S. Temporo-sphenoidal lobe. A.F. Ascending frontal convolution. A.P. Ascending parietal convolution. f_1, f_2, f_3. Superior, middle, and inferior frontal convolutions, separated by the superior and inferior frontal sulci. p_1, p_2. Superior and inferior parietal convolutions, separated by the inter-parietal fissure. o_1, o_2, o_3. Superior, middle, and inferior occipital fissures. t_1, t_2, t_3. Superior, middle, and inferior temporo-sphenoidal fissures.

Some of the sulci, from their depth, regularity, and early period of development, are termed the *primary* or *interlobular fissures*, and map out the surface of the cerebrum into five lobes. Of these sulci there are three: the *fissure of Sylvius*, the *fissure of Rolando* or *central fissure*, and the *parieto-occipital* or occipital *fissure* (Fig. 274).

* For an account of these laminæ, see Lockhart Clarke, *Proceedings of the Royal Society*, 1863.

The *fissure of Sylvius* is seen on the base of the cerebrum, where it receives the lesser wing of the sphenoid bone. It begins outside the locus perforatus anticus or praecribrium, as a deep triangular depression — *vallecula Sylvii* — and then curves outwards as a deep cleft to the external surface of the cerebrum; it divides into two rami—an ascending or vertical, about an inch (*2.5 cm.*) in length, and a posterior or horizontal ramus, which passes backwards and slightly upwards, and ends at the posterior third of the cerebrum by a bifid extremity. Within the fissure, near its commencement, a series of convolutions

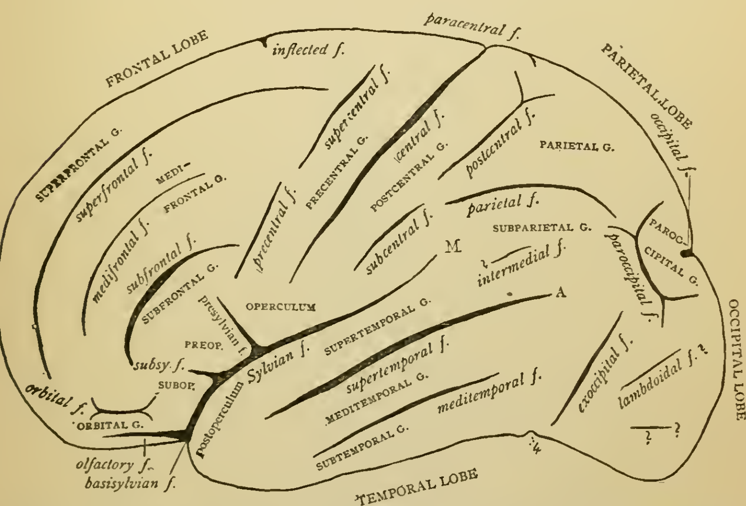


FIG. 274 (B). — FISSURES AND GYRI ON THE LATTER SURFACE OF THE LEFT HEMISPHERE. (From Wilder.)

may be seen deeply placed; these are called the *gyri operti*, the *island of Reil* or *insula*. In the fork between the two rami of the Sylvian fissure are several convolutions, which have been termed by Broca the *operculum of the insula*.

The *fissure of Rolando or central fissure* (Fig. 274, A) runs obliquely over the outer convex surface of the hemisphere. It commences close to the longitudinal fissure about its middle, from which it is separated by the marginal convolution. It then runs obliquely downwards and forwards, and terminates a little above the fork of the Sylvian fissure. As seen in Fig. 275, the two fissures form a V-shape, failing to be joined at the angle.

The fissure is formed, in early fœtal life, by a large vein, which subsequently atrophies, and is rarely bridged over.

The *parieto-occipital* or *occipital fissure* (Fig. 275, P.O.*f.*) is seen on the median surface of the hemisphere, towards its posterior part. It begins as a deep cleft on the median surface, about half an inch (*13 mm.*) behind the callosum, then ascends nearly vertically, and ends on the external aspect of the cere-

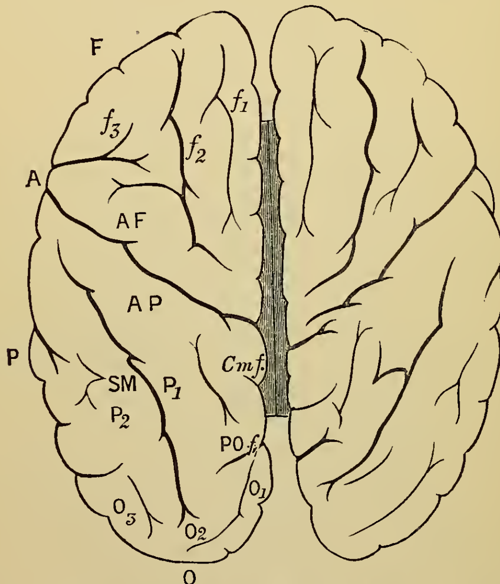


FIG. 275.—CONVOLUTIONS OF THE UPPER SURFACE OF THE BRAIN.

A. Fissure of Rolando. A.F. Ascending frontal or precentral convolution. A.P. Ascending parietal or postcentral convolution. S.M. Supra-marginal convolution, below which is the angular gyrus. P.O.*f.* Parieto occipital fissure. F. Frontal lobe. P. Parietal lobe. O. Occipital lobe. $f_1 f_2 f_3$. Superior, middle, and inferior frontal convolutions. P_1, P_2. Superior and inferior parietal convolutions. O_1, O_2, O_3. Superior, middle, and inferior occipital convolutions. *C.m.f.* Calloso-marginal fissure.

brum, about an inch (*2.5 cm.*) beyond the longitudinal fissure; this latter portion taking the name of the *external parieto-occipital fissure.*

The fissure of Sylvius is first seen about the middle of the third month of fœtal life, and is caused by the extension backwards, and folding upon itself, of the *mantle;* the fissure of Rolando begins to be developed about the fifth month, and the parieto-occipital fissure between the third and fourth month of uterine life.

The primary fissures form the boundaries of the various lobes of which each hemisphere is composed.

The *frontal lobe* is that part of the front portion of the cerebrum, bounded behind by the fissure (central) of Rolando, below by the ascending part of the fissure of Sylvius, and on the median plane by the calloso-marginal or supercallosal fissure. Its inferior part rests on the anterior fossa, is separated from the tempero-sphenoidal lobe by the main portion of the Sylvian fissure, and is called the *orbital surface,* while its convex external surface is called the *frontal surface.*

The convolutions on its frontal surface are four in number: The *ascending frontal* or *precentral convolution* (Figs. 274, A.F.) which bounds, in front, the fissure of Rolando, and is usually connected above and below the fissure with the ascending parietal or postcentral convolution; the union below forming the *operculum,* the union above part of the *paracentral lobule;* the upper and the lower union of these two convolutions thus shut off the fissure of Rolando from joining the fissure of Sylvius below, and the longitudinal fissure above.

The *superior, middle,* and *inferior frontal convolutions* (Figs. 274, f_1, f_2, f_3,) course nearly horizontally; the *superior* runs along the margin of the longitudinal fissure, the *inferior* along the lower border of the lobe, arching over the ascending ramus of the Sylvian fissure'; the *middle* is placed between these. In front of the ascending frontal convolution is a vertical fissure, *precentral sulcus,* which prevents the frontal convolutions joining the former convolution.

The sulci which map out the frontal convolutions are two, the *superior* and *inferior frontal sulci.*

On the *orbital surface* there is a deep sulcus, the *tri-radiate sulcus,* whose rami pass forwards, outwards, and backwards, mapping this surface out into internal, anterior, and posterior orbital convolutions (Fig. 276, *Tr. s.*).

On this surface also we find the *olfactory lobe,* lodged in a deep cleft, the *olfactory sulcus* (Fig. 276, *Olf. s.*), and although it will be described under the cranial nerves, it is strictly a cerebral lobe, for it is developed as a distinct outgrowth from the anterior cerebral vesicle; moreover, in early fœtal life it possesses a cavity continuous with the general ventricular cavity of the brain.

The *parietal lobe* (Fig. 274 P) is placed between the central fissure and the external parieto-occipital or occipital fissure, and is bounded below by the horizontal limb of the fissure of Sylvius, and by a line continued from it to meet one passing down from the parieto-occipital fissure.

The convolutions of the parietal lobe are three: The *ascending parietal* or *postcentral convolution* is bounded in front by fissure of Rolando, and runs parallel with the ascending frontal convolution in front, which it joins above and below the fissure. The *superior parietal* or *parietal convolution* (Figs. 274) is placed above the interparietal or parietal fissure, and courses horizontally backwards; posteriorly it runs beneath the parieto-occipital fissure, and is connected with the superior occipital convolution; this is known as the *first annectent convolution;*

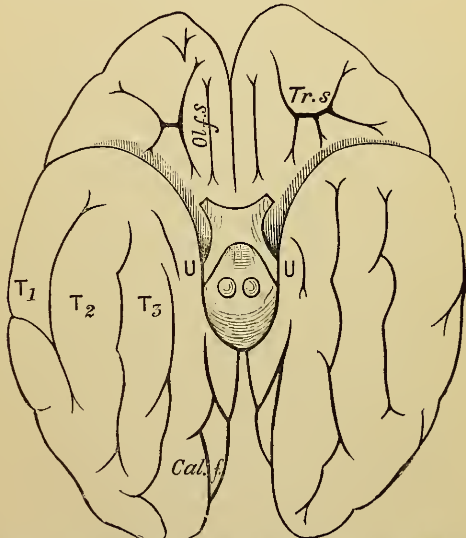


FIG. 276.—CONVOLUTIONS OF THE BASE OF THE CEREBRUM.

Olf. s. Olfactory sulcus. *Tr. s.* Tri-radiate sulcus. U. Ucinate convolution. *Cal. f.* Calcarine fissure. T_1, T_2, T_3. Superior, middle, and inferior temporo-sphenoidal convolutions.

this convolution is also seen on the median surface of the cerebrum. The *inferior parietal* or *sub-parietal convolution* lies below the interparietal fissure, and consists of two portions: one, the *supra-marginal,* lies in front of the posterior ramus of the Sylvian fissure; the other, the *angular* gyrus (Fig. 274 B, M), lies behind the fissure of Sylvius, and bends over the termination of the parallel sulcus; the angular convolution is connected behind with the occipital convolutions by the *second* and *third annectent convolutions.*

The *interparietal* or *parietal fissure* may ascend at first nearly

vertically, connecting with the sub-central, and then runs horizontally backwards from the ascending parietal convolution.

The *occipital lobe* (Fig 274, O) consists of the posterior part of the hemispheres behind, bounded in front by the external parieto-occipital fissure, and by a line continued from it to the notch on the basal surface made by contact with ridge lodging the superior petrosal sinus.

The convolutions on the external surface are three:

The *superior*, *middle*, and *inferior occipital convolutions* * (Fig. 275, o_1, o_2, o_3) run nearly horizontally backwards, and are separated by the superior and inferior occipital fissures; anteriorly these convolutions are continuous with the parietal and temporo-sphenoidal convolutions, through the four *annectent gyri*. The first three have been previously described; the lowest or fourth connects the inferior occipital with the inferior temporo-sphenoidal convolution.

There is usually a small, shallow, vertical fissure, the *transverse occipital* or *paraoccipital*, which passes down behind the external parieto-occipital fissure.

On the median plane is the *cuneate lobule*, which forms part of the occipital lobe, and will be described further on.

The *temporo-sphenoidal lobe* (temporal lobe) is bounded in front and above by the fissure of Sylvius and its horizontal ramus, and forms that part of the hemisphere which occupies the middle cerebral fossa.

The convolutions of this lobe are three:—

The *superior temporo-sphenoidal* or *super-temporal* (Fig. 276, T_1) is bounded above by the horizontal ramus of the Sylvian fissure, and below by the parallel fissure; it is continuous behind with supra-marginal and angular gyri. The *middle temporo-sphenoidal* or *mid-temporal* is joined behind to the angular gyrus and to the middle occipital convolution through the third annectent gyrus; the *inferior* or *sub-temporal* is connected with the inferior occipital convolution through the fourth annectent gyrus.

There are three fissures running from before backwards, the *superior temporo-sphenoidal* or *supertemporal*, the *midtemporal*, and the *inferior* or *subtemporal*.

The convolutions and fissures of the mesial and tentorial surfaces can only be properly examined by making an antero-pos-

* The naming of these fissures and convolutions is still a disputed point. See Fig. 274 B. (A. H.)

terior vertical section of the brain through the longitudinal fissure. As this would spoil the brain for future demonstration, the student is recommended to examine one in which this section has been already made.

The *fissures* to be examined on this surface are the callosal, the calloso-marginal or supercallosal, the paracentral, the internal parieto-occipital or occipital, the calcarine, the collateral and the hippocampal or dentate.

The *convolutions* excluding of course the mesial portion of the first or superfrontal are the precuneus, the cuneus, the

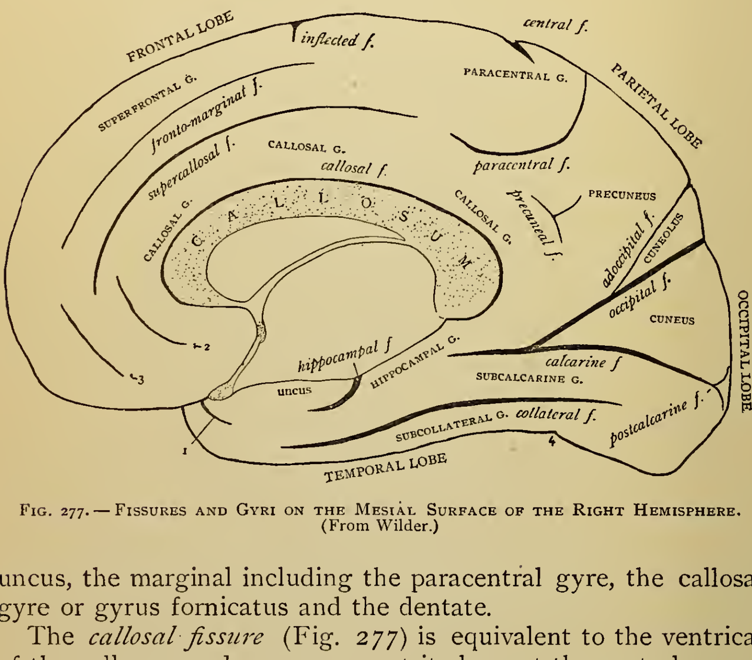


FIG. 277.—FISSURES AND GYRI ON THE MESIAL SURFACE OF THE RIGHT HEMISPHERE. (From Wilder.)

uncus, the marginal including the paracentral gyre, the callosal gyre or gyrus fornicatus and the dentate.

The *callosal fissure* (Fig. 277) is equivalent to the ventrical of the callosum and commences at its base at the ventral aspect of the precribrium, and follows the curve of the callosum from its genu to the basal aspect of its splenium, where it joins with the hippocampal fissure terminating in the notch of the uncus.

The *callosal-marginal* or *supercallosal fissure* is placed between the callosal gyre beginning in front of the genu of the callosum and extends backwards parallel to the margin of the paracentral gyre, and by some is continuous with the paracentral fissure with the anterior two-thirds of the callosum; then changing its

direction it ascends obliquely and terminates on the lateral aspect of the hemisphere where it makes a deep notch behind the central fissure. The posterior one-third of this fissure is known as the paracentral fissure, and is sometimes completely separated from the supercallosal fissure.

The *internal parieto-occipital* or *occipital fissure* passes obliquely downwards and joins the calcarine fissure at the acute angle, and is itself joined by an additional fissure known as the ad-occipital which separates the dorsal margin of the precuneus from the cuneolus, the remaining boundary of the cuneolus being the occipital fissure.

The *calcarine fissure* begins close to the dorsal border of the cerebrum by two forks (post calcarine f.) and then running nearly horizontally forwards is joined by the occipital; it terminates at the basal margin of the hippocampal gyre; it corresponds with the hippocampus minor (calcar) in the dorsal horn of the lateral ventricle.

The *collateral fissure* is situated below the calcarine and runs parallel with it for a short distance in the occipital lobe; it separates the subcalcarine of the lingual portion of the occipital lobe from the subcollateral gyre or inferior temporal convolutions. Farther forward on the temporal lobe it separates the hippocampal gyre and this same temporal gyre extending slightly beyond the hippocampal fissure.

The *hippocampal* or *dentate fissure* starts at the basal portion of the splenium of the callosum and continues in an oblique direction downwards and forwards to form the notch in the uncus. It corresponds to the hippocampus in the lateral horn of the lateral ventricle.

The *precuneus* or *quadrate lobe* is bounded in front by the paracentral fissure or the continuation of the supercallosal fissure, behind by the adoccipital and occipital fissure, below and in front by the precuneal fissure, and above by the mesial margin of the parietal lobe. It forms the mesial portion of the parietal lobe and consists of several convolutions connected with the callosal gyre.

The *cuneus* or *cuneate lobe* is bounded in front by the occipital fissure, below by the calcarine fissure, and behind by the mesial margin of the occipital lobe between the fissure above named. The cureolus, a small triangular convolution seen on the mesial surface, is separated from the precuneus by the adoccipital fissure.

The *uncus* or *uncinte gyre* is a hook-shaped gyre situated on the mesial surface of the temporal lobe in front of the hippocampal fissure.

The *marginal gyri* include those gyri located on the mesial surface, separated from the callosal gyre and precuneus by the supercallosal and paracentral fissures (calloso-marginal fissure) embracing portions of the mesial surfaces of the frontal and pariental lobes. It is frequently indented by secondary fissures.

The *callosal gyre* or gyrus fornicatus consists of an arched convolution which is placed on the mesial surface and extends from the precribrium around the genu and splenium of the callosum to the uncus of the temporal lobe. It is separated from the contiguous portions of the frontal and parietal lobes by the supercallosal and paracentral fissures (these two together equaling the calloso-marginal), and precuneal fissures from the remaining portion of the parietal, occipital and temporal lobes by the occipital and calcarine fissures. It is separated from the callosum by the callosal and hippocampal or dentate fissure. The interval made by the callosal fissure is very deep and is often called the ventricle of the callosum. The margin of the convolution is termed the *labrium cerebri.* It includes the hippocampal gyre or the superior temporal convolution, and connects with the precuneus and is itself constricted by the encroachment of the occipital and calcarine fissures to form its isthmus. The group of convolutions together with the septum lucidum, fornix, cornu ammories, fiascia dentata, fasciola cinerea, mesial and lateral longitudinal striae, and the peduncles of the callosum forms the *Falciform* or *Limbic lobe.* There is thus formed almost a complete circle from the locus perforatus anticus or precribrium to the uncus.

The *dentate gyre* (fascia dentata) consists of serrated and abortive gray area found in the depth of the hippocampal fissure extending from the basal aspect of the splenium to the notch in the uncus. It takes its name from the notched appearance it presents, owing to the arrangement of the choroid arteries as they pass in through the fissure into the descending horn of the lateral ventricle.

The *island of Reil, insula* or the *central lobe,* lies deeply in the fissure of Sylvius, not far from its commencement. It is triangular in shape, the apex being close to the anterior perforated spot, and from it radiate outwards five or six short convolutions (*gyri operti*), which are separated from the operculum

by a deep fissure. In the normal position of the brain it forms the floor of the lenticular nucleus of the corpus striatum. It appears very early in fœtal life, and is at first very prominent, but subsequently becomes closed in by the increasing development of the temporo-sphenoidal lobe.

Nomenclature of the Parts at the Base of the Brain. — The several objects seen at the base of the brain should now be examined, proceeding in order from the front (Fig. 278). In this description the cerebral nerves are omitted. These will be examined hereafter.

In front we notice the triangular frontal lobes, separated from each other by the longitudinal fissure, and bounded behind by the fissure of Sylvius.

In the middle line, dividing the frontal lobes, is the longitudinal fissure. By gently separating these lobes, we expose the corpus callosum, or the great transverse commissure which connects the two hemispheres of the cerebrum. Continued backwards and outwards on each side from the corpus callosum to the fissure of Sylvius is a white band, the peduncle of the corpus callosum. Extending from the corpus callosum to the optic commissure is a thin gray layer, the lamina cinerea. Between the frontal and temporo-sphenoidal lobes is the fissure of Sylvius, which lodges the middle cerebral artery. The optic commissure, formed by the union of the two optic tracts, is seen in the middle line behind the lamina cinerea. At the root of the fissure of Sylvius is the locus perforatus anticus or precribrium.* Immediately behind the optic commissure is a slight prominence of gray matter, the tuber cinereum; from this descends a conical tube of reddish color, the infundibulum, to the apex of which is attached the pituitary body or hypothesis. Behind the tuber cinereum are two round white bodies, the corpora albicantia. Posterior to these is the locus perforatus posticus or postcribrium, which is bounded behind by the pons, and laterally by the two diverging crura cerebri, two round cords of white substance which emerge from the anterior border of the pons. Winding round the outer side of each crus is a soft white band, the optic tract.

Examine now in detail the various objects above enumerated, most of which are shown in Fig. 280.

The *longitudinal fissure* is visible in front, where it separates

* Called *perforatus* from its being perforated by a number of blood-vessels for the supply of the corpus striatum.

the two frontal lobes, and, by lifting up the cerebellum, it can be seen behind dividing the occipital lobes. It can be more satisfactorily examined later on.

The *lamina cinerea* is a thin layer of gray substance, which runs backwards from the termination of the corpus callosum,

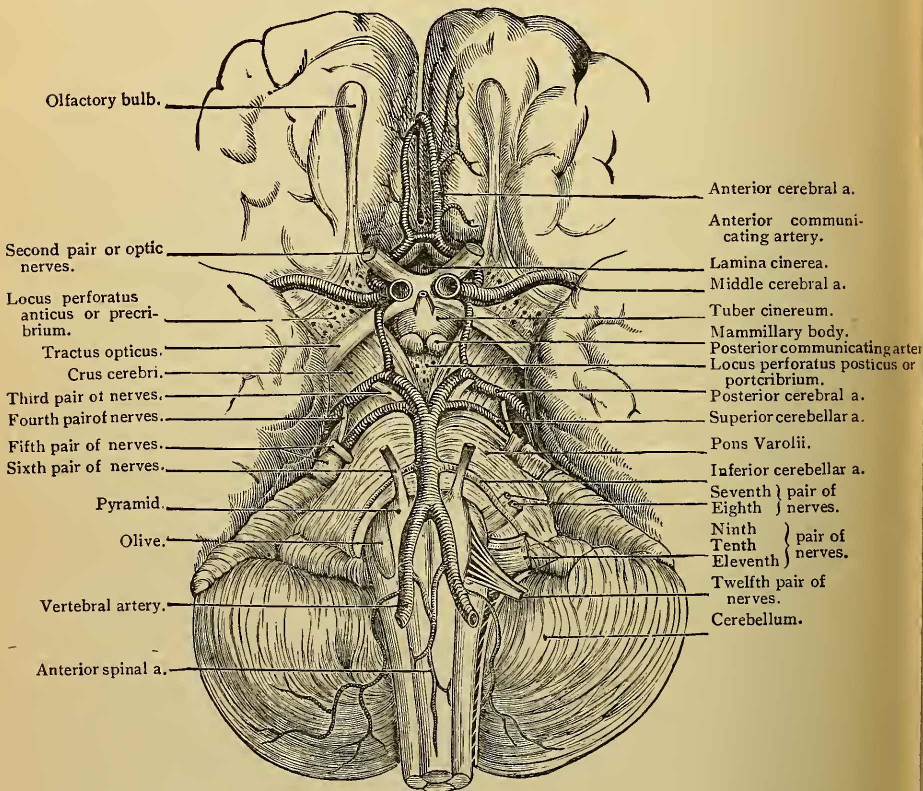


Fig. 278.

and passes above the optic commissure to be connected with the tuber cinereum. Laterally, it is continuous with the gray matter of the two anterior perforated spots. If the lamina be torn, which is very easily done, an opening is made into the anterior part of the floor of the third ventricle.

The *olfactory lobe* lies in its own sulcus on the orbital surface, nearer its mesial aspect.

The *optic commissure* is placed immediately behind the lamina

cinerea. It is formed by the junction in the middle line of the two optic tracts. From it the two optic nerves can be traced, running forwards and outwards.

The *locus perforatus anticus* (*Precribrium*) is a shallow triangular depression, placed to the inner side of the commencement of the fissure of Sylvius. It is bounded in front by the two diverging white roots of the olfactory lobe, and behind by the optic tract. It is composed partly of gray substance, and is continuous with the lamina cinerea on the inner side. Crossing it is seen a broad white band, the *peduncle of the corpus callosum.* This space is pierced by a number of small apertures for the transmission of small vessels to the corpus striatum; hence its name.

The *tuber cinereum* (Fig. 278) is a prominence of gray matter immediately behind the optic commissure, and in front of the corpora albicantia. It forms part of the floor of the third ventricle, and from it a conical tube of reddish color, the *infundibulum,* descends to the posterior lobe of the pituitary body. There is a large collection of gray matter on the outer side of the tuber cinereum, and internal to the optic tract, called the *basal optic ganglion,* from which fibres pass to the corresponding optic tract.

The *pituitary body* or *hypophisis* occupies the sella turcica, is of a reddish-brown color, and consists of two lobes. Of its two lobes, the anterior and larger is concave posteriorly, to receive the posterior lobe, and weighs from five to ten grains ($\frac{1}{3}$ *to* $\frac{2}{3}$ *gm.*). The two lobes consist of different structure, and differ in their development; the *posterior* is developed downwards from the third ventricle, and is hollow; subsequently there is a large increase of connective-tissue structure and blood-vessels in it, so that the cavity is usually obliterated. The *anterior* is darker, and is surrounded by a connective-tissue capsule; on section it resembles in structure the thyroid gland, being composed of reticular tissue, with numerous cavities filled with nucleated cells and granular matter; it is originally developed as a prolongation from the ectoderm of the buccal cavity, from which it soon becomes isolated.

The *corpora albicantia* (*mammillaria*) are two round white bodies, situated behind the tuber cinereum. Each is formed by the curl upon itself of the anterior crus of the fornix, called the *bulb of the fornix,* which then turns backwards and upwards to end in the optic thalamus, as the fibres of Vicq. d' Azyr.

They contain within them some gray matter, and up to the seventh month of fœtal life they form one mass.

The *locus perforatus posticus* (*postcribrium*) is a depression of gray matter placed between the diverging crura cerebri and behind the corpora albicantia. Its surface is penetrated by small vessels which supply the optic thalami. From its gray substance some white fibres emerge and turn round over the crura cerebri to enter the white medullary portion of the cerebellum.

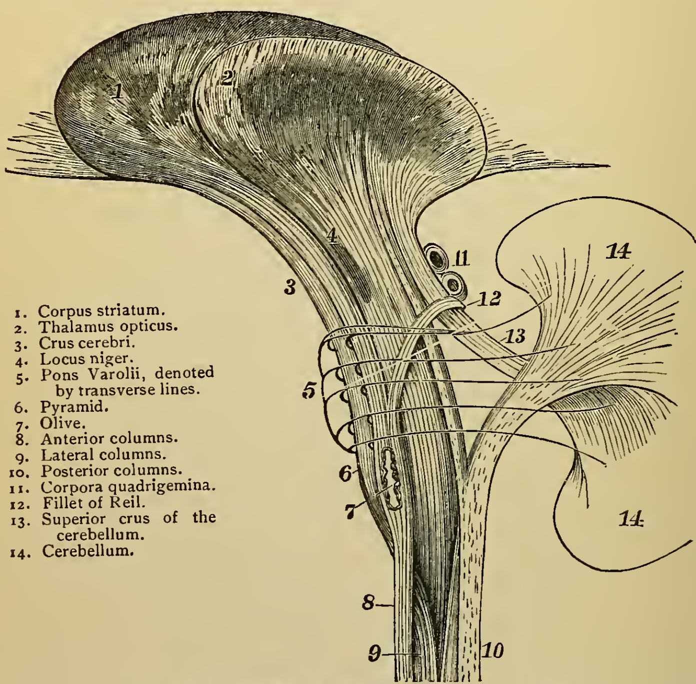


Fig. 279.—Diagram of the Course of the Fibres through the Medulla and Pons.

The *crura cerebri* (Fig. 278) are the two rounded masses of white matter which emerge from the anterior border of the pons Varolii, and then pass forwards and outwards to enter the anterior and inner aspect of the temporo-sphenoidal lobes. Each is about three-quarters of an inch (*18 mm.*) long, and is rather broader in front than behind. On the inner side the third nerve is seen emerging from a groove (*oculo-motor*) in the crus, which marks the division of the crus into two portions, an upper (dorsal) and larger called the *tegmentum*, and a lower, or ventral,

called the *crusta*. The optic tract curves round the anterior part of each crus, and is adherent to it by its anterior border.

Structure of the Crura Cerebri. — These are composed of longitudinal fibres, derived from the pyramids, from part of the lateral and restiform columns of the medulla, and from the gray matter in the pons Varolii. If one of the crura be divided longitudinally, there is found in the middle of it a layer of dark-colored nerve-substance, called *locus niger*, which separates the crus into an upper and lower stratum of fibres. The lower stratum (*crusta*) is tough and coarse, and consists of the continuation of the fibres proceeding from the pyramid and the pons. The upper stratum (*tegmentum*) is much softer and finer in texture; it is composed of the fibres proceeding from the lateral and restiform columns; also from the superior crus of the cerebellum. Tracing the fibres of the crus cerebri into the cerebral hemisphere, we find that its lower fibres ascend chiefly through the corpora striata, its upper fibres through the thalami optici. In passing through these ganglia, the crus receives a large addition to its fibres; these branch out widely towards all parts of the hemisphere, in order to reach the cortical substance on the surface.

Origin of the Cerebral Nerves. — The *cerebral nerves* are given off in pairs, named the first, second, third, etc., according to the order in which they appear, beginning from the front. There are twelve pairs. Some are nerves of special sense — as the olfactory, the optic, the auditory; others are nerves of common sensation — as the larger root of the fifth, the glosso-pharyngeal, and the pneumogastric; others, again, are nerves of motion — as the third, the fourth, the smaller root of the fifth, the sixth, the facial, the spinal accessory, and the hypoglossal.

First Pair or Olfactory Nerves. — These (Fig. 280, 1) are from their early development outgrowths from the cerebral lobes, and not, strictly speaking, nerves. The nerve is triangular on section, the apex of the triangle being lodged in a straight furrow (*olfactory sulcus*) in the orbital surface of the frontal lobe. It proceeds straight forwards, and terminates in the olfactory bulb, which lies on the cribriform plate of the ethmoid bone.

The olfactory lobe is oval, of a reddish-gray color and very soft consistence, owing to the large amount of gray matter contained in it. It gives off from its under surface about twenty branches, which pass through the foramina in the cribriform plate.* For description of these, see vol. I., p. 283.

* The olfactory nerve and its ganglion, as stated above, are integral parts (the prosencephalic lobe) of the brain. What in human anatomy is called the origin of the nerve is, in point of fact, the crus of the olfactory lobe, and is in every way homologous to the crus cerebri or cerebelli. In proof of this, look at the enormous size and connections of the crus in animals which have very acute sense of smell. Throughout the vertebrate kingdom there is a strict ratio between the sense of smell and the development of the olfactory lobes. Again, in many animals these lobes are actually larger than the cerebral, and contain in their interior a cavity which communicates with the lateral ventricles. According to Tiedmann, this cavity exists even in the human fœtus at an early period.

The nerve arises by two roots — an outer and an inner, composed of white matter (Fig. 280).

The *outer root* passes backwards and outwards as a thin white line, along the outer side of the locus perforatus anticus, to the commencement of the fissure of Sylvius.

Its deeper origin has been traced to a nucleus of gray matter in the anterior part of the temporo-sphenoidal lobe.

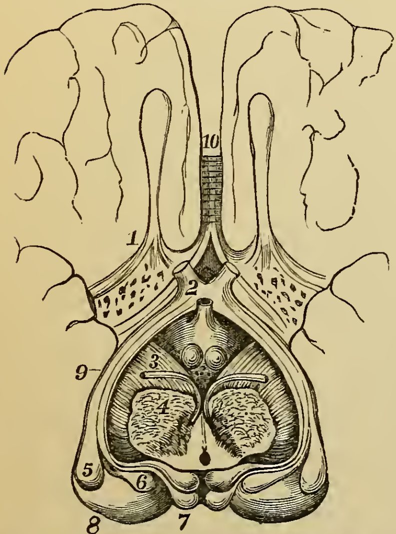


FIG. 280. — DIAGRAM OF THE ORIGINS OF THE OLFACTORY AND OPTIC NERVES.

1. Olfactory lobe. 2. Optic n. 3. Crus cerebri. 4. Section of crus to show locus niger. 5. Corpus geniculatum externum. 6. Corpus geniculatum internum. 7. Corpora quadrigemina. 8. Thalamus opticus. 9. Tractus opticus. 10. Corpus callosum.

The *inner root* passes backwards and inwards to the posterior extremity of the internal convolution of the frontal lobe, and thence may be traced to the gyrus fornicatus.

Between the two roots may be seen the olfactory tubercle arising from the gray matter of the sulcus in which the nerve is lodged, and from the gray matter of the locus perforatus anticus in the fork between them. It contains white fibres in its interior, which have been traced to the corpus striatum.

Second Pair or Optic. — The *optic tracts* arise from the anterior lobes (*nates*) of the corpora quadrigemina, the corpora geniculata, and the posterior part of the optic thalami (Fig. 280). They wind round the crura cerebri, with which they are connected by their anterior borders, and, after receiving some fibres from the basal optic nucleus join in the middle line to form the *optic commissure.* This commissure rests upon the sphenoid bone in front of the sella turcica, and from it each optic nerve, invested by its fibrous sheath, passes through the optic foramen into the orbit and terminates in the retina.

At the commissure some of the nerve-fibres cross from one side to the other. This decussation affects only the middle fibres of the nerve; the outer fibres pass from one optic tract to the optic nerve of the same side; the inner fibres pass from one optic tract round to the optic tract of the opposite side. (Fig. 283, p. 733.)

Third Pair or Motores Oculorum. — The apparent origin of the *third nerve* is from the inner side of the crus cerebri, immediately in front of the pons.

Some of its roots, however, pass through the locus niger and the tegmentum of the crus, to reach a nucleus of large yellow cells beneath the iter e tertio ad quartum ventriculum (*Aqueduct of Sylvius*), extending forwards as far as the posterior commissure, and behind as far as the nucleus of the fourth nerve (see below).

It runs forwards through the cavernous sinus, and, passing through the sphenoidal fissure in two divisions, supplies all the muscles of the orbit except the superior oblique and the external rectus.

Fourth Pair or Trochlear Nerves. — The *fourth nerve* has its deep origin from a nucleus of gray matter in the floor of the aqueduct of Sylvius, beneath the corpora quadrigemina, and almost continuous superiorly with the yellow nucleus of the third nerve. The nerve fibres then run backwards, upwards, and inwards in the lateral wall of the Sylvian aqueduct, and reach the anterior part of the valve of Vieussens, where they cross over to the opposite side.

The nerve then emerges from the valve of Vieussens close to the middle line, and, winding round the crus cerebri, enters the orbit through the sphenoidal fissure and supplies the superior oblique.

Fifth Pair or Trigeminal Nerves. — The *fifth nerve* is the largest of all the cranial nerves, and consists of two roots, a larger or sensory, and a smaller or motor. It has its appparent origin from the outer side of the pons Varolii, and a few of the transverse fibres of this body separate the two roots of the fifth.

The *motor* or *smaller root* consists of fibres which take origin from an oval gray nucleus (*motor nucleus*) situated in the front part of the floor of the fourth ventricle, internal to its lateral boundary; in their passage forwards the fibres are joined by filaments from the descending root of the fifth, which arise from the gray matter in the lateral wall of the aqueduct of Sylvius, beneath the anterior lobes of the corpora quadrigemina. It also receives some fibres from the raphé. The *sensory* and *larger root* arises by fibres having their origin chiefly in the *superior sensory nucleus*, which is situated external to the motor nucleus, and partly by fibres known as the ascending fibres, which may be traced far down in the medulla from a mass of nerve-cells in connection with the gray tubercle of Rolando and its upward prolongation.

The two divisions of the nerve proceed forwards over the apex of the petrous portion of the temporal bone; here is developed, upon the sensory root, the Gasserian ganglion. The root then divides into three branches — the *ophthalmic*, which passes through the sphenoidal fissure; the *superior maxillary*, which passes through the foramen rotundum; the *inferior maxillary* or mandibular, which passes through the foramen

ovale. They all confer common sensation upon the parts they supply, which comprise the entire face and sides of the head. The small motor root passes beneath the ganglion, with which it has no connection, and accompanies the mandibular division, to be distributed to the muscles of mastication. For a more detailed description of the three divisions of this nerve see pages 66, 150, 269, Vol. I.

Sixth Pair or Abducentes. — The *sixth nerve* emerges from the transverse groove between the pons and the anterior pyramid (Fig. 278), with both of which it is connected.

Its deep origin can be traced to an oval gray mass of nerve-cells in the fasciculus teres in the floor of the fourth ventricle, close to the median groove and in front of the transverse striæ. The nerve fibres pass downwards from their origin through the pons parallel with the septum, and emerge from the transverse groove as before stated.

It leaves the skull through the sphenoidal fissure, and, passing between the two heads of the external rectus, is distributed to this muscle.

Seventh Pair or Facial Nerves.— The *facial nerve* or *portio dura* (Fig. 278) has its apparent origin from the groove between the pons and the restiform tract, and behind the olivary body.

Its deep origin may be traced to an elongated mass of gray substance, placed deeply in the floor of the fourth ventricle, between the motor nucleus of the fifth and the transverse striæ. From this origin its fibres run upwards, backwards, and inwards to the floor of the fourth ventricle, and wind round the nucleus of the sixth, so as to course superficial to it in the fasciculus terès. The nerve then makes a sharp bend upon itself, and passes downwards and outwards through the pons between the superior olivary nucleus and the ascending root of the fifth nerve. A small separate fasciculus of this nerve — *pars intermedia* — lies between it and the auditory nerve, and forms connections with both; it arises from the lateral column of the cord.

The nerve enters the meatus auditorius internus. For the further description of the portio dura, see p. 275, Vol. I.

Eighth Pair or Auditory Nerves. — The *auditory nerve* emerges from the same groove as the preceding nerve, and is situated immediately beneath it, being separated from it only by the pars intermedia.

Its deep origin is principally from the *inner auditory nucleus*, situated in the floor of the fourth ventricle, under the tuberculum acusticum; this nucleus extends from beneath the acoustic tubercle to the middle of the anterior half of the floor, passing beneath the tranverse striæ; on its inner side, below, is the vagal nucleus; on its outer side is the restiform body; from this nucleus the fibres pass

outwards, and, on curving round the restiform body, are joined by some filaments from the transverse striæ. A few of the filaments of the auditory nerve come from another nucleus situated in front of the medullary striæ and external to the preceding nucleus, and which gets larger as it passes upward.

These two bundles unite, and the nerve passes outwards and enters the meatus auditorius internus in company with the portio dura. It divides at the bottom of the meatus into cochlear and vestibular branches, which are distributed to the internal ear.

Ninth Pair or Glosso-pharyngeal Nerves. — The *glosso-pharyngeal nerve* arises apparently by several filaments from the restiform body below the auditory nerve.

Its deep origin is from a nucleus in the inferior fovea of the fourth ventricle, continuous behind with the vagal nucleus, and covered in front by the inner auditory nucleus.

The glosso-pharyngeal nerve passes through the middle compartment of the foramen jugulare, and is distributed to the mucous membrane of the pharynx and back of the tongue, p. 156, Vol. I.

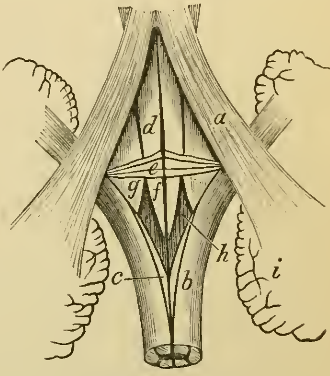


FIG. 281. — VIEW OF THE FLOOR OF THE FOURTH VENTRICLE.

a. Superior peduncles of the cerebellum. *b*. Restiform tracts. *c*. Posterior pyramids. *d*. Fasciculus teres: external to it is the superior fovea. *e*. Striæ acusticæ. *f*. Fasciculus teres. *g*. Tuberculum acusticum. *h*. Inferior fovea. *i*. Cerebellum.

Tenth Pair or Pneumogastric Nerves. — The *pneumogastric nerve* arises from a gray nucleus (divided into two by a bundle of white fibres), which is placed between the glosso-pharyngeal nucleus in front and the spinal accessory nucleus behind, in the inferior fovea.

The fibres, about twelve in number, pass through the medulla, and emerge from the restiform body, below the glosso-pharyngeal, and join to form a single nerve. This passes through the foramen jugulare, separated from the preceding by a septum of dura, and is distributed to the pharynx, larynx, the heart and lungs, the œsophagus and stomach. See Vol. I, pp. 159, 201, 275.

Eleventh Pair or Spinal Accessory Nerves. — The *spinal accessory nerve* is composed of two parts: an upper or accessory portion, which arises from the medulla below the vagus, and a lower or spinal portion, which arises from the spinal cord.

The accessory fibres may be traced to the gray nucleus, which is connected in front with the vagal nucleus, and lies close to the median sulcus of the fourth ventricle, extending to the apex of the calamus scriptorius and along the side of the central canal; the spinal portion may be traced below to the tractus intermedio-lateralis and anterior cornu, and above to the posterior cornu, arising by slender filaments as low down as the fifth or sixth cervical vertebra.

The spinal portion ascends behind the ligamentum denticulatum, through the foramen magnum, into the skull, and joins the accessory part. The nervus accessorius then passes through the foramen jugulare with the two preceding nerves; its accessory portion joins the pneumogastric nerve, and its spinal portion supplies the sterno-mastoid and the trapezius. The course and distribution of this nerve has been described in the dissection of the head and neck.

The Twelth or Hypoglossal Nerves. — The *hypoglossal nerve* arises by several filaments from the medulla, which emerge from the groove between the anterior pyramid and the olivary body.

Its fibres may be traced to a long gray nucleus which forms an eminence in the floor of the fourth ventricle, in front and to the inner side of the vagal nucleus.

The filaments are collected into two fasciculi, which pierce the dura through two apertures and join in the anterior condylar foramen; it is distributed to the muscles of the tongue and the depressor muscles of the os hyoides and larnyx, Vol. I, p. 118, 162.

Dissection of the Brain. — The brain should now be laid on its base. We first notice a median fissure, separating the cerebrum into two symmetrical hemispheres; this is the *longitudinal fissure.* By gently separating the hemispheres we see that the fissure extends in front and behind to the base, but that in the middle there is at the bottom a white band of nerve-substance, which is the great transverse commissure of the cerebrum, and termed the *corpus callosum*, upon which are seen the two anterior cerebral arteries.

Slice off the hemispheres to about half an inch (*13 mm.*) above the level of the corpus callosum. The cut white surface presents an oval appearance and is called the *centrum ovale minus.* The white substance is surrounded by a tortuous layer of gray matter about one-eighth of an inch (*3.3 mm.*) in thickness. This gray substance consists of four layers — two of gray alternating with two of white, the most external layer being white. In some places, chiefly at the base of the brain,

six layers have been demonstrated. The white substance is spotted with red dots (*puncta vasculosa*); these are due to the escape of blood from the divided vessels. The corpus callosum is now seen to be overlaid on each side by the gyrus fornicatus; the border is termed the *labium cerebri*, and the space between the gyrus and the corpus callosum is called the *ventricle of the corpus callosum* or *callosal fissure*.

Now slice off the hemisphere down to the level of the corpus callosum, when a section is made of the white substance, called the *centrum ovale majus*. The corpus callosum is now well exposed.

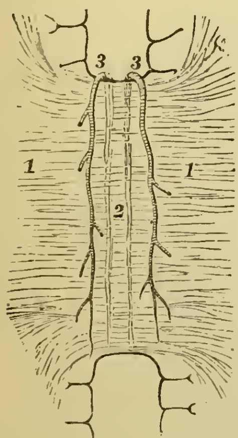


FIG. 282.—UPPER SURFACE OF CORPUS CALLOSUM.

1, 1. Lineæ transversæ. 2. Raphé. 3, 3. Anterior cerebral a.

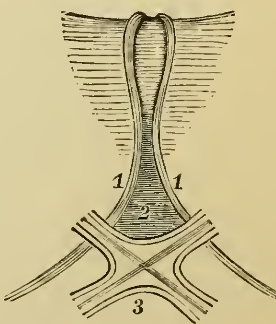


FIG. 283.—DIAGRAM OF LAMINA CINEREA.

1, 1. Peduncles of corpus callosum. 2. Lamina cinerea. 3. Commissure of optic nerves.

Corpus Callosum.—This stratum of white substance, consisting of transverse commissural fibres, is the chief connecting medium between the two hemispheres, and is called the *great transverse commissure* of the cerebrum; and moreover on each side forms the roof of the lateral ventricles. Its surface is slightly arched from before backwards; it is about four inches (*10 cm.*) long and one inch (*2.5 cm.*) in its greatest breadth, which is behind. It is rather nearer to the front than to the back part of the brain, and it is thicker at the ends than in the middle, and thicker behind than in front. A shallow groove called the *raphé* runs along the middle of the upper surface (Fig. 282); in a fresh brain, two longitudinal white tracts,

named *striæ longitudinales*, or the *nerves of Lancisi*, run parallel to it; and external to these again are two other longitudinal fibres, *striæ longitudinales laterales*. The surface of the corpus callosum is marked by transverse lines which indicate the course of its fibres; these are the *lineæ transversæ* of the old anatomists. The anterior cerebral arteries proceed along the surface of the corpus callosum to the back of the brain.

The anterior part of the corpus callosum turns downwards and backwards, forming a bend called its *genu*. The inferior

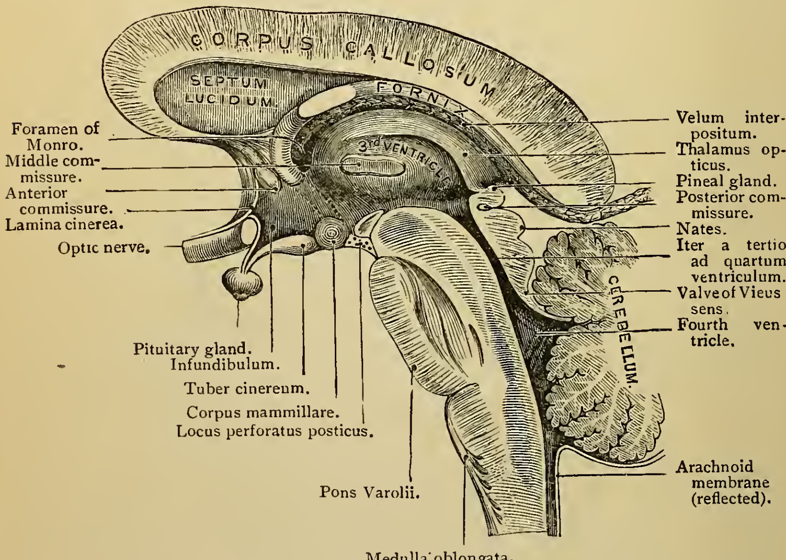


FIG. 284.—VERTICAL SECTION THROUGH THE CORPUS CALLOSUM, AND PARTS BELOW.

part of this bend — *rostrum* — becomes gradually thinner and narrower, and terminates in two peduncles, which diverge from each other and are lost, one in each fissure of Sylvius. Between these crura is placed the lamina cinerea (Fig. 283, p. 733). The posterior part of the corpus callosum terminates in a thick, round border — the *splenium* — which is free, and beneath it the pia enters the interior of the ventricles. A satisfactory view cannot be obtained of the arch formed by the corpus callosum, of its terminations in front and behind, and of the relative thickness of its different parts, without making a

perpendicular section through a fresh brain, as shown in the preceding figure.*

Connected with the under surface of the posterior part of the corpus callosum is the fornix, which separates from it in front, the two structures being connected by a vertical septum — the *septum lucidum* (Fig. 284).

Lateral Ventricles. — A longitudinal incision should be made on each side through the corpus callosum about half an inch (*13 mm.*) from its median raphé. Care must be taken not to cut too near the middle line, in order to preserve the delicate partition which descends from the under surface of the corpus callosum, and separates the ventricles from each other. Two cavities, called the *lateral ventricles*, will thus be exposed, one in each cerebral hemisphere, and they should afterwards be laid open throughout their whole extent. Their general form should be first examined; then the several objects seen in them.

The *lateral ventricles* are two serous cavities, one in each hemisphere of the brain. They are occasioned by the enlargement and folding backward of the cerebral lobes over the other parts of the central nervous axis. They contain a serous fluid, which, even in a healthy brain, sometimes exists in considerable quantity; when greatly in excess it constitutes one form of the disease termed hydrocephalus. The ventricles are lined with ciliated epithelium, laid upon a layer of neuroglia (*ependyma*); a term which has been applied to that peculiarly delicate connective tissue found throughout the brain and spinal cord.

The ventricles are crescentic in shape, with their backs towards each other. Each consists of a central part or *body*, and three horns or *cornua* — *anterior*, *middle*, and *posterior* — which extend, respectively, into the frontal, temporo-sphenoidal, and occipital lobes. The body, situated in the middle of the hemisphere, is triangular in shape, and is separated from its fellow by the septum lucidum. Its roof is formed by the corpus callosum (Fig. 286, 1); internally, it is bounded by the septum lucidum (Fig. 284); on the floor, beginning from the front, are seen the *corpus striatum*, the *tænia semicircularis*, the *optic thalamus*, the *choroid plexus*, and the *corpus fimbriatum* of the *fornix* (Fig. 285).

* The corpus callosum is more or less developed in all mammalia, but is absent in birds, reptiles, and fish. It has been absent in the human subject without any particular mental deficiency. See cases recorded by Reil, *Archiv. für die Phys.* t. xi., and Wenzel, *De penitori Struct. Cereb.*, p. 302.

The *anterior horn* extends into the frontal lobe, and as it passes forwards it diverges slightly from its fellow of the opposite side. It is triangular in shape; its roof and anterior wall are formed by the corpus callosum, and it curves round the anterior extremity of the corpus striatum.

The *posterior horn* can be traced into the occipital lobe, where it passes at first backwards and outwards, and then, narrowing to a point, converges towards its fellow. Its roof is formed by the fibres of the corpus callosum as they pass backwards and

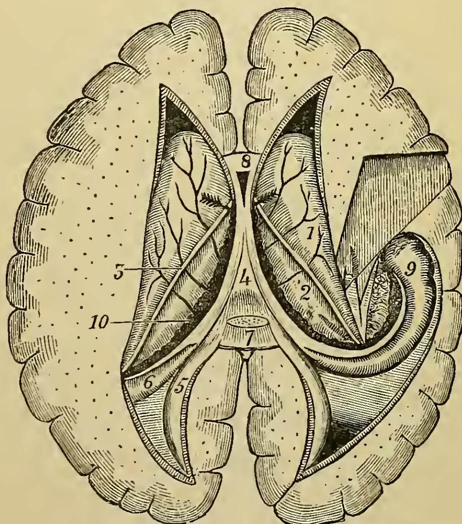


FIG. 285.—VIEW OF THE LATERAL VENTRICLES FROM ABOVE AFTER THE REMOVAL OF THE CORPUS CALLOSUM.

1. Corpus striatum. 2. Optic thalamus. 3. Tænia semicircularis. 4. Fornix. 5. Hippocampus minor. 6. Hippocampus major, with the eminentia collateralis behind it. 7. The corpus callosum (cut through). 8. Fifth ventricle. 9. Pes Hippocampi. 10. Choroid plexus.

outwards from the splenium; on its floor are seen on the inner side an eminence, the *hippocampus minor* or *calcar*, and external to it a triangular flat surface, called the *pes accessorius* or *eminentia collateralis*.*

The *middle* or *descending horn* runs into the temporo-sphenoidal lobe, descends towards the base of the brain, making a

* The posterior horns are not always equally developed in both hemispheres, and sometimes they are absent in one or both.

In the carnivora, ruminantia solipeda, pachydermata, and rodentia, the lateral ventricles are prolonged into the largely developed olfactory lobes. This is the case in the human fœtus at an early period.

curve, at first backwards and outwards, then downwards and forwards, and lastly inwards; the initial letters of which make the memorial word "*bodfi.*" Its roof is formed by the fibres of the corpus callosum, partly by the posterior narrow extremity of the corpus striatum, with the tænia semicircularis, and the rounded extremity of the optic thalamus. On its floor are the *hippocampus major*, a large rounded white eminence which follows the curve of the cornu; the *pes hippocampi*, the expanded paw-like extremity of the former; the *eminentia collateralis* on the outer side of the hippocampus major, and part of which is seen in the posterior horn; the *corpus fibriatum* of the fornix, attached to the anterior concave border of the hippocampus

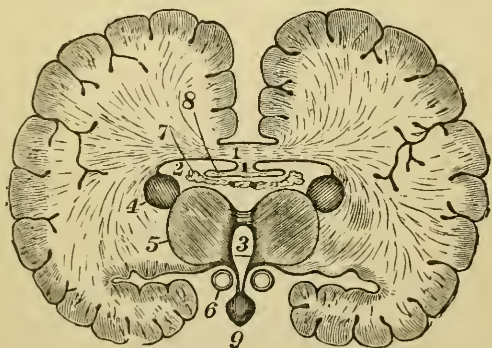


FIG. 286.—TRANSVERSE VERTICAL SECTION THROUGH THE BRAIN.

1 Corpus callosum. 2. Lateral ventricle. 3. Third ventricle. 4. Corpus striatum. 5. Thalamus opticus. 6. Corpus mammillare. 7. Choroid plexus. 8. Fornix. 9. Pituitary gland.

major; the *fascia dentata*, a crimped edge of gray matter under the corpus fimbriatum; the *choroid* plexus, and the outer part of the *transverse fissure*.

The various structures seen in the body and horns of the lateral ventricle will be described later on, when they are fully exposed.

Appearance on Perpendicular Section.—If a vertical transverse section is made across the middle of the brain, the lateral ventricles would appear as represented in Fig. 286. Observe that the roof and the floor are almost in actual contact, unless separated by ventricular fluid. Together with the third or middle ventricle, their shape slightly resembles the letter T. Such a section shows well the radiating fibres of the corpus callosum, the fornix, and the velum interpositum beneath it;

also the beginning of the transverse fissure at the base of the brain, between the crus cerebri and the temporo-sphenoidal lobe.

If the corpus callosum be slightly raised, a thin vertical median septum, *septem lucidum*, will be seen, extending from the under aspect of this body to the upper surface of the fornix.

Septum Lucidum. — This is a thin and almost translucent partition which descends vertically in the middle line from the under surface of the corpus callosum, and separates the anterior part of the lateral ventricles from each other. It is attached above to the callosum, below to the reflected part of the callosum and fornix (Fig. 284). It is not of equal depth throughout. Its broadest part is in front and corresponds with the knee (*genu*) of the corpus callosum. It becomes narrower behind, tapering to a thin point, where the callosum and the fornix become continuous. The septum consists of two layers, which enclose a space called the *fifth ventricle* or the *ventricle of the septum* (Fig. 285). Each layer consists of gray matter inside and of white matter outside; the former representing the cortical, the latter the medullary substance of the brain. The cavity is not lined with epithelium, as is the case with those ventricles developed from the cerebral vesicles.*

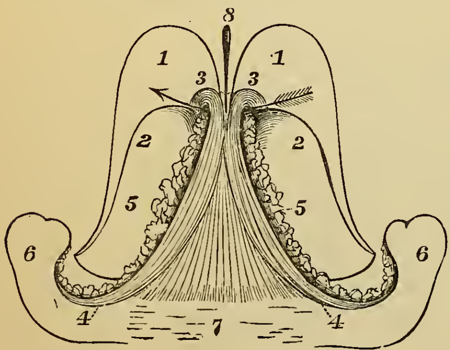


FIG. 287.— DIAGRAM OF THE FORNIX.

(The arrow is passed through the foramen of Monro.)

1, 1. Corpora striata. 2, 2. Thalami optici. 3, 3. Anterior crura of fornix bending down to join the corpora mammillaria. 4. 4. Posterior crura of the fornix joining the hippocampi. 5, 5. Choroid plexus. 6, 6. Hippocampi majores. 7. Corpus callosum cut through. 8. Ventricle of septum lucidum.

Cut transversely through the callosum about its middle, with the septum lucidum, and turn forwards the anterior half. In this way the ventricle of the septum will be exposed. By turning back the posterior half of the callosum a view is obtained of the fornix. This proceeding requires care, or the fornix will be

* The development of the septum lucidum commences about the fifth month of fœtal life, and proceeds from before backwards, *pari passu* with the callosum and the fornix. It is developed from the lower part of the great longitudinal fissure, but becomes shut off from it in the process of development.

reflected also, since these two arches of nerve-substance are here so closely connected.

Fornix. — The *fornix* is a layer of white matter, extending in the form of an arch (whence its name) from before backwards, beneath the callosum. It is the great longitudinal white commissure, and lies over the velum interpositum (Fig. 287). Viewed from above, it is triangular with the base backwards, and is called the *body;* from its anterior narrow part are given off the *two anterior crura*, and from its posterior and outer part the *two posterior crura.*

The *body* is the broad triangular part with the narrow portion in front. The posterior broad part is connected with the callosum; in front of this it arches downwards, so as to leave the callosum, to which, however, it is still connected by the septum lucidum. Its lateral free edges rest on the choroid plexuses, and are seen on the floor of the lateral ventricles.

The *anterior pillars* or *crura* proceed from the front narrow part of the body, one on each side of the mesial line. As they pass forwards the crura diverge slightly, and descend through a mass of gray matter in the sides of the third ventricle towards the base of the brain, where, making a sudden bend upon themselves, they form the corpora mammillaria, from which they may be traced backwards and upwards, each to the anterior nucleus of the optic thalamus of its own side. As they descend, the anterior crura are joined by the peduncles of the pineal body, by the tænia semicircularis, and by fibres from the septum lucidum. Immediately behind and below the anterior crura is a triangular passage, through which the choroid plexuses of opposite sides are continuous with each other. This aperture is called the *foramen of Monro.* Strictly speaking, it is not a foramen, but only an interval caused by the anterior crus arching over the groove between the striatum and thalamus on each side; it establishes a communication between the two lateral and third ventricles, and is in shape like the letter Y, the passage from each lateral ventricle passing downwards and inwards, and meeting below, to be continued as a single passage for a short distance before opening into the third ventricle.

The *posterior pillars* or *crura* are continued downwards and outwards from the thickened free borders of the body of the fornix, and are at first connected to the under surface of the corpsus callosum. Each leaves the body at the posterior and outer angle as a thin flat white band resting on the choroid

plexus and the pulvinar of the thalamus, and curving downwards and outwards, becomes intimately connected with the concave border of the hippocampus major as far down as the pes hippocampi, gradually tapering to a point at its termination. The free border of the posterior crus is known as the *tænia hippocampi* or the *corpus fimbriatum*; and on raising this up we expose an indented layer of gray matter, the *fascia dentata*, which is the free border of the cortical substance of the cerebrum.*

The fornix should now be cut through transversely, and its two portions reflected backwards and forwards respectively. On the under surface of the posterior portion are seen fibres, passing transversely, belonging to the callosum, and forming what is termed the *lyra*.

Between the fornix and the upper surface of the cerebellum is the *transverse fissure*, or *fissure of Bichat*, through which the pia enters the ventricles. The fissure extends from the middle downwards on each side to the base of the brain, as far as the end of the descending horn. It is of a horse-shoe shape, with the concavity directed forwards. The upper boundary of that part of the transverse fissure which extends into the middle horn is sometimes called the *free margin of the hemisphere*.

The contents of the lateral ventricles should now be examined more in detail.

Corpus Striatum. — The *corpus striatum* is so called because, when cut into, it presents alternate layers of a white and gray substance. It is a large ovoid mass of gray substance, part of which forms an eminence in the body of the lateral ventricle (the intraventricular portion); but the larger part (extraventricular portion) is embedded in the white substance of the cerebrum. The *intraventricular portion*, called the *nucleus caudatus*, is pear-shaped, broad in front, and when traced backwards is found to taper gradually to a point on the outside of the thalamus (Fig. 288). Its surface is of a pinkish-gray color, and is crossed by numerous small veins (*venae corporis striati*) which open into the venæ Galeni. When a horizontal cut is made into it, it shows a thin layer of white substance covering a mass of gray streaked with white. The *extraventricular portion*, or *nucleus lenticularis*, can only be seen on a

* The fornix and septum lucidum are absent in fish; they are merely rudimentary in reptiles and birds; but all mammalia have them in greater or less perfection, according to the degree of development of the cerebral hemispheres.

horizontal section being made outwards; the section reveals a biconvex mass of gray matter, separated from the nucleus caudatus by a broad band of white substance, the *internal capsule*, and corresponds with the island of Reil. Running parallel with the outer border of the nucleus lenticularis, but separated from it by a thin layer of white substance, the *external capsule*, is a wavy streak of gray matter, the *claustrum*, of variable thickness. Outside the claustrum is another layer of white matter, and then we see the indented convolutions of the island of Reil. If a vertical transverse section be made through the nucleus lenticularis, it appears triangular and intersected by two white lines, which divide it into three parallel gray bands. Beneath the lenticular nucleus is a mass of gray matter, called the *nucleus amygdalae*, which causes an elevation at the apex of the roof of the middle horn.

Taenia Semicircularis.—The *tænia semicircularis*, or *stria terminalis*, is a narrow semi-transparent band of longitudinal white fibres, which lies in the groove between the striatum and the thalamus (Fig. 288, 3). In front, it is connected with the anterior crus of the fornix, and descends with it to the corpus mammillare; it passes backwards and outwards, and behind it is lost in the white substance of the middle horn of the lateral ventricle. Several veins from the striatum pass underneath the tænia semicircularis to join the venæ Galeni. The upper surface of the tænia is firmer in structure than its deeper part, and is called the *horny band* of Tarinus.

Hippocampus Major.—The *hippocampus major* is an elongated convex eminence of gray matter, covered with white, and is situated in the posterior part of the descending horn. It extends to the bottom of the horn, following its curve, where it becomes somewhat expanded and indented on the surface, so as to resemble the paw of an animal, whence its name, *pes*. Attached to the front concave border of the hippocampus is the posterior crus of the fornix. It corresponds to the hippocampal fissure, which itself is filled with gray matter, which forms the fascia dentata.

Hippocampus Minor.—The *hippocampus minor*, called also *calcar*, is a rounded eminence, smaller than the preceding, occupying the inner curved wall of the posterior horn. It consists of white matter externally, and corresponds to the calcarine fissure. Between the hippocampus major and minor is a triangular smooth surface, called the *pes accessorius*, or *eminentia*

collateralis, and is found in the posterior and the descending horn. This corresponds to the collateral fissure.

Velum Interpositum and Choroid Plexus. — The *velum interpositum* or *tela*, which supports the fornix, should now be examined. This is a double layer of pia which penetrates into the ventricles through the transverse fissure, beneath the posterior border of the corpus callosum, as shown in Fig. 288. The shape of this vascular membrane is like that of the fornix,

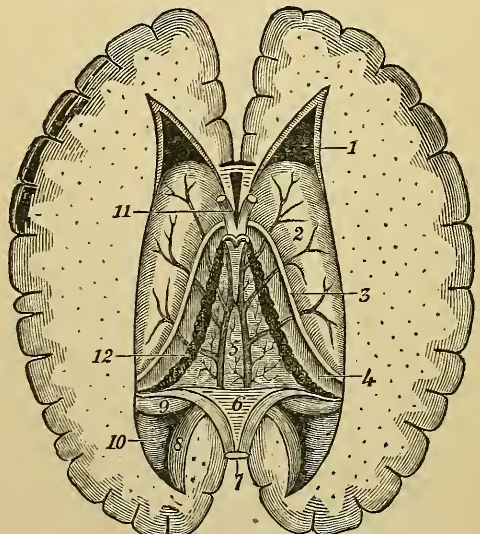


FIG. 288. — VIEW OF THE LATERAL VENTRICLES AND THE VELUM INTERPOSITUM AFTER REFLECTING THE FORNIX.

1. Anterior horn. 2. Corpus striatum. 3. Tænia semicircularis. 4. Optic thalamus. 5. Velum interpositum, with the venæ Galeni. 6. Lyra. 7. The posterior half of the fornix turned backwards. 8. Hippocampus minor. 9. Hippocampus major. 10. Eminentia collateralis. 11. Fifth ventricle. 12. Choroid plexus.

and its borders project beneath that body and form the red convoluted fringes called the *choroid plexuses*. These plexuses consist almost entirely of tortuous ramifications of minute bloodvessels, and are covered with vascular villi. The villi themselves are covered with large spheroidal epithelial cells. In front the plexuses communicate with each other through the foramen of Monro; behind, they descend into the middle horns of the lateral ventricles, and become continuous with the pia at the base of the brain. From the under surface of the velum two

small vascular processes are prolonged into the third ventricle, forming the *choroid plexuses* of that cavity.

Venæ Galeni. — Along the centre of the velum run two large veins called *venæ Galeni*, which return the blood from the ventricles into the straight sinus.

The velum interpositum, with the choroid plexuses, must now be removed to expose the following structures shown in Fig. 290 (p. 746) : — 1. A full view of the *optic thalamus*. 2. Between the optic thalami is the *third ventricle*, a deep vertical fissure, situated in the middle line. 3. Behind the fissure is the *pineal body*, (*epiphysis cerebri*) a vascular structure, about the size of a pea. From this body may be traced forwards two slender white cords, called its *peduncles*, or *striæ pineales* — one along the inner side of each optic thalamus. 4. Passing transversely across the third ventricle are *three commissures* — anterior, middle, and posterior, connecting the opposite sides of the brain. 5. Immediately behind the epiphysis are four elevations, two on each side, called the *corpora quadrigemina*, or *nates* and *testes*. 6. These bodies are connected with the cerebellum by two bands, one on each side, termed the *processus e cerebello ad cerebrum* or *ad testes, i.e., superior peduncles*. 7. Between these cords extends a thin layer of gray substance, called the *valve of Vieussens*, beneath which lies the fourth ventricle.

Thalamus Opticus. — This, called also the *posterior cerebral ganglion*, is the convex oval elevation seen immediately behind the striatum and tænia semicircularis. Superficially it is covered with a thin layer of white, but internally it is composed of gray substance. The under surface rests upon the tegmentum of the crus cerebri, and forms part of the roof of the middle horn of the lateral ventricle ; externally it is bounded by a broad band of white substance derived from the crusta, which forms the internal capsule, already described. Externally, the thalamus is bounded by the tænia semicircularis ; superficially, it is covered by the choroid plexus and the fornix ; internally, it forms the lateral boundary of the third ventricle, and has, running along it, the peduncle of the pineal body ; posteriorly, it overlaps the sides of the corpora quadrigemina, and forms a prominence in the roof of the middle horn, where it receives the crus cerebri. The upper surface of the thalamus is divided into two portions by an oblique shallow groove, passing from before backwards ; the anterior and outer

portion forms a prominent convex surface, called the *anterior tubercle,* which is covered with the epithelium of the lateral ventricle; the posterior and inner portion is pointed in front, and posteriorly enlarges to form a pointed rounded eminence, the *posterior tubercle* or *pulvinar,* and is not lined with epithelium.* Beneath the posterior part of the thalamus are two small oval eminences, termed the *corpora geniculata, internum* and *externum.* These consist of small accumulations of gray matter, beneath the white; the outer one being situated external to and above the internal, and to the outer side of one of the roots of the optic tract (Fig. 280, p. 728). From each of these bodies proceeds a white band to join the root just referred to, and from the junction of these three roots (*brachia*) the optic tract has its commencement. A narrow band of white substance connects the external one with the nates, and a similar band connects the internal one with the testes.†

Third Ventricle. — The *third ventricle* is the long, narrow fissure between the thalami, and reaches down to the base of the brain. Its *roof* is formed by the fornix and the velum interpositum, the under aspect of which is lined by the epithelium covering the general ventricular cavities, and is reflected from the velum and choroid plexuses on to the thalami; the *floor,* which increases in depth in front, is formed by certain parts at the base of the brain, found within the interpeduncular space, viz., the locus perforatus posticus, corpora mammillaria, tuber cinereum, infundibulum, and lamina cinerea, all of which are best seen in a vertical section (Fig. 291). In *front,* it is bounded by the anterior crura of the fornix and the anterior commissure; *laterally,* by the thalami and the peduncles of the pineal body; *behind,* by the posterior commissure and the *iter e tertio ad quartum ventriculum,* or aqueduct of Sylvius, which is a long canal beneath the corpora quadrigemina, connecting the third with the fourth ventricle.

Commissures. — Passing across the third ventricle are seen three commissures, the anterior, middle, and posterior.

Middle. — The *middle commissure* may be seen by gently separating the optic thalami, and is about half an inch (*13 mm.*) in breadth. This is composed entirely of gray substance, and,

* There is a triangular depression between the pulvinar and the peduncle of the pineal body, which has received the name of the *trigonum habenulæ.*

† These bands are faintly marked in man, but are more apparent in the lower animals.

in most brains, owing to its softness, is generally torn before it can be examined.*

Anterior. — The *anterior commissure* is a round white cord, which lies immediately in front of the anterior crura of the fornix, and connects the corpora striata. This commissure may be traced on each side through the corpora striata, below the nuclei lenticulares, extending backwards far into the temporo-sphenoidal lobes.

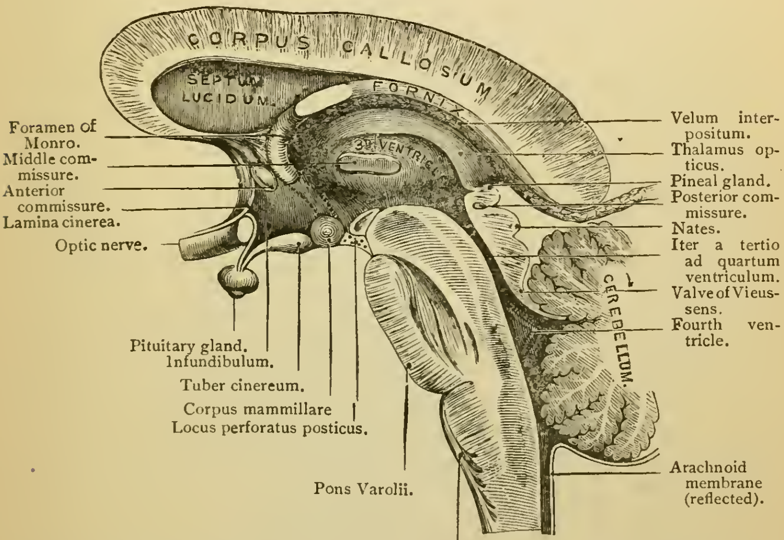


FIG. 289.—VERTICAL SECTION THROUGH THE CORPUS CALLOSUM, AND PARTS BELOW.

Posterior. — Situated immediately in front of, and rather below the pineal body, is another thin round white cord called the *posterior commissure.* Its fibres pass into the substance of the hemispheres and connect the optic thalami. Its fibres are derived from the fillet which comes from the tegmentum of the crus cerebri.

* The soft commissure does not appear to be a very essential constituent part of the brain. It is not found before the ninth month of fœtal life, and in some instances, according to our observations, is never developed. Wenzel states that it is absent in about one out of seven subjects (*De penitiori Struct. Cerebri Hom. et Brut.* Tübingen, 1812).

The third ventricle communicates with the lateral ventricles by the two openings of the foramina of Monro, with the fourth ventricle through the iter e tertio ad quartum ventriculum, and in front of its floor by a conical cavity, *iter ad infundibulum*, with the infundibulum.

The third ventricle is covered with an epithelial lining continuous with that of the lateral ventricles through the foramina

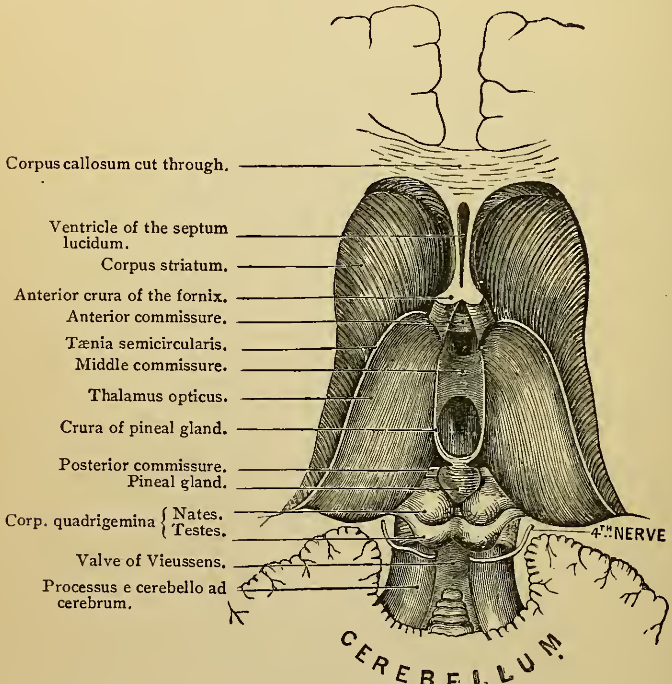


FIG. 290.

of Monro; after covering the walls of the third ventricle it lines the aqueduct of Sylvius to pass to the fourth ventricle.

Pineal Gland or Epiphysis Cerebri. — The *pineal body* is a very vascular oval body, situated immediately in front of the corpora quadrigemina (Fig. 290). It is about the size of a cherry-stone, and is firmly connected with the under surface of the velum, and is apt to be separated from its normal position when that membrane is reflected. It is connected to the cerebrum by two white crura, the *peduncles of the pineal gland*,

which extend forwards, one on the inner side of each optic thalamus along their upper margin, and terminate by joining the anterior crura of the fornix. The peduncles join together behind in front of the pineal body, and are connected with the front of the posterior commissure.

The pineal body consists of numerous small follicles filled with cells, which are separated by connective tissue, so that in structure it much resembles that of the anterior lobe of the pituitary body. In its interior it contains, besides some viscid fluid, more or less gritty particles (*acervulus cerebri*), consisting of phosphate and carbonate of lime, and phosphate of magnesia and ammonia. Besides the calcareus particles, these follicles contain corpora amylacea ; and, when abundant, this sabulous matter is found on the peduncles of the pineal body.

The pineal body is larger in the female than in the male subject, and is largest of all in the child. It is found in all mammalia, birds, and reptiles, in the same typical position, but its functions are entirely unknown.

Corpora Quadrigemina. — The *corpora quadrigemina* are four round eminences, situated two on each side, behind the pineal gland, and are separated from each other by a crucial depression. Though white on their surface, they contain gray matter in their interior for the purpose of giving origin to the optic tract. Laterally, they are continued outwards as two convex white cords, the *anterior* and *posterior brachia.* The anterior brachium passes between the corpora geniculata, and is continued on into the optic tract, of which it may be considered its direct root ; the posterior brachium passes forwards and outwards, and is lost beneath the corpus geniculatum internum. They are situated above the iter e tertio ad quartum ventriculum. The anterior pair are called the *nates*, and are larger and darker than the posterior pair, which take the name of *testes.* A more appropriate term for these bodies would be the optic lobes.*

The corpora quadrigemina are developed very early in fœtal life, and are at first only two in number, one on each side of the

* Eminences homologous to the corpora quadrigemina are found in all vertebrate animals; they are the mesocephalic lobes; they always give origin to the optic nerves, and their size bears a direct relation to the power of sight. They are relatively smaller in man than in any other animal. In birds there are only two eminences, and these are very large, especially in those far-seeing birds which fly high, as the eagle, falcon, vulture, etc., who require acute sight to discern their prey at a distance.

mesial line; but about the seventh month a transverse groove is apparent, thus mapping out the four bodies.*

Processus e Cerebello ad Cerebrum. — By gently drawing back the overlapping cerebellum, two broad white cords are seen, which pass backwards, diverging from each other, from the optic thalami and the corpora quadrigemina to the cerebellum (Fig. 290). These are the *processus e cerebello ad cerebrum*, or *superior peduncles of the cerebellum.* They connect the cerebrum and cerebellum, and rest upon the crura cerebri. Below they pass to the inferior vermiform process, and to the white matter within the corpus dentatum.

Valve of Vieussens. — The triangular space between the superior peduncles is occupied by a thin layer of gray matter, which covers over the anterior part of the fourth ventricle. This layer is called the *valve of Vieussens*, or the *anterior* or *superior medullary velum;* it is narrow in front and broad posteriorly, where it is connected with the central portion of the cerebellum. Along the mesial line of its upper surface there is an irregular ridge, the *frænulum*, which becomes lost towards its lower part; the lower part is overlapped by a corrugated lobule of gray matter from the anterior part of the cerebellum, and is called the *linguetta laminosa.*

Iter e Tertio ad Quartum Ventriculum, or Aqueduct of Sylvius. — The third ventricle is connected with the fourth by a canal (Fig. 289) large enough to admit a probe, which runs downwards and backwards beneath the posterior commissure and the corpora quadrigemina. It is about half an inch (*13 mm.*) in length, and its shape varies in different parts of its course; in the lower being T-shaped, and in the upper part shield-shaped, on transverse section. In its walls is a large amount of gray matter, in which are the nuclei of origin of the third, fourth, and upper part of the fifth cranial nerves. It is lined with ciliated columnar epithelium. This passage, together with the third and fourth ventricles, are persistent parts of the central canal, which in early fœtal life extended down the middle of the cerebro-spinal axis. It subsequently becomes much

* On making a transverse vertical section through the nates, we find that there is a superficial thin layer of white fibres (stratum zonale); beneath this is a crescentic layer of gray matter (stratum cinereum); deeper than this is a thick biconvex mass of gray matter, with nerve filaments and nerve cells (stratum opticum); and lowest of all is an arched layer of white nerve fibres derived from the fillet (stratum lemnisci).

encroached upon by the large increase of gray substance in the process of development.

Fourth Ventricle. — The fourth ventricle is the space situated between the cerebellum behind and the posterior surface of the medulla oblongata and pons Varolii in front. It is the dilated portion of the primordial canal alluded to in the last paragraph. If viewed in a vertical section, as represented in the diagram (Fig. 289), it appears triangular, with its base forwards; but if seen from behind, it is a lozenge-shaped space, the long axis being antero-posterior (Fig. 291).

The *upper wall* or *roof* of the fourth ventricle is formed by the valve of Vieussens, and by the front of the inferior vermiform process, with the two amygdalæ; *laterally* it is bounded, in front by the processus e cerebello ad cerebrum, and behind by the diverging restiform bodies; *below*, by the continuation of the arachnoid on to the posterior surface of the spinal chord, in which there is an aperture called the *foramen of Magendie; in front* its floor is formed by the medulla oblongata and pons Varolii. The pia is prolonged for a short distance into the lower part of the cavity, and forms *choroid plexus of the fourth ventricle* or metatela.

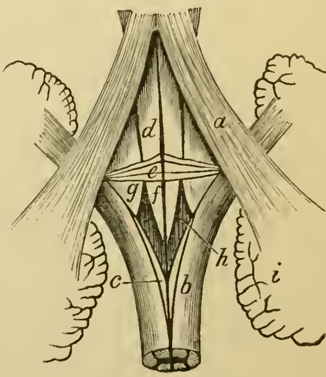


Fig. 291. — Floor of the Fourth Ventricle.

a. Processus e cerebello ad cerebrum. *b*. Restiform bodies. *c*. Fasciculi graciles. *d*. Fasciculus teres, externally is the fovea superior. *e*. Medullary striæ. *f*. Fasciculus teres. *g*. Tuberculum acusticum. *h*. Fovea inferior. *i*. Cerebellum.

The anterior wall is diamond-shaped, pointed above and below, while laterally the space broadens out into an angular point, between the cerebellum and the medulla, called the *lateral recess*. Below, the ventricle is bounded by the restiform bodies and the clava, the former diverging like the branches of the letter V to form the *inferior peduncles* of the *cerebellum*; the divergence of these cords, with the median fissure, was called by the older anatomists the *calamus scriptorius*, from its fancied resemblance to a writing pen. At the termination of the posterior pyramid there is a slight overhanging thickening turning over the restiform body at the lateral recess, of which

it forms the lateral boundary; it is called the *ligula* or *tænia.* We find also a similar thickening, partly of the lining membrane and partly of nerve-matter, arching over the apex of the calamus scriptorius, known as the *obex.*

The *floor*, formed by the posterior surface of the medulla and pons, is marked by a median groove passing from the apex of the calamus scriptorius to the iter. It is divided into two portions, a lower and an upper, by some transverse white fibres called the *striæ acusticæ* or *medullares*, which emerge from the median groove and pass outwards over the inferior cerebellar peduncle to join part of the roots of the auditory nerves. The lower part of the floor, on each side, is mapped out into three surfaces by a triangular depression, *fovea inferior* (Fig. 291, *h*), having its apex at the transverse striæ, and its base below at the posterior pyramids. On the outer side of the fovea there is a convex triangular surface, with its base upwards (Fig. 291, *g*), called the *tuberculum acusticum ;* on the inner side of the fovea and bounded internally by the median groove, is the rounded triangular surface which marks the commencement of the *fasciculus teres.* Towards the base of the inferior fovea there is a dark surface of gray matter called the *ala cinerea*, which becomes raised into an eminence (*eminentia cinerea*).

The upper part of the fourth ventricle is that portion between the acoustic striæ and the iter e tertio ad quartum ventriculum. The median groove is still continued upwards, although it becomes fainter, and on each side of it is the parallel rounded eminence, the *fasciculus teres.* Outside this fasciculus is a triangular depression, the *fovea superior ;* and passing upwards under cover of the superior cerebellar peduncle, we notice a depression of gray substance, called the *locus cæruleus.*

The lower part of the fourth ventricle is developed from the metencephalic, the upper part from the epencephalic portion of the posterior primary vesicle.*

Structure of the Cerebrum. — The white substance of the cerebrum consists of medullated fibres, which are, as a rule, smaller than those in the spinal cord.

The general arrangement of the fibres may be classified

* Tiedemann proposed to call the fourth ventricle the first, because in the fœtus it is formed sooner than any of the others; because it exists in all vertebrated animals, whereas the lateral ventricles are absent in all osseous fishes; and because the ventricle of the septum lucidum is absent in all fishes, in reptiles, and in birds.

under three heads: (1) The diverging or peduncular fibres; (2) The transverse commissural fibres; and (3) The longitudinal fibres.

The *diverging* or *peduncular fibres* are derived partly from the crusta and partly from the tegmentum of the crus cerebri. Those from the crusta pass forwards and outwards between the nucleus caudatus and nucleus lenticularis with the internal capsule; and in front of the ganglia the fibres radiate outwards in all directions, called the *corona radiata.* Most of these fibres pass indirectly to the cortical portion of the cerebrum; some proceed direct to the cortex, through the gray ganglionic structure, amongst which are the *pyramidal tract,* passing to the gray matter in the neighborhood of the fissure of Rolando, and the *direct sensory tract* to the cortex of the occipital lobe. The fibres from the tegmentum are joined by others from the processus e cerebello ad cerebrum, and the corpora quadrigemina, and pass under the optic thalamus, and probably through this body, and radiate outwards, joining the corona radiata to proceed to the temporo-sphenoidal, post-parietal, and occipital lobes.

The *transverse commissural fibres* connect the two hemispheres, and are the corpus callosum, the anterior and posterior commissures.

The *longitudinal fibres* consist of the fornix, the striae longitudinales of the corpus callosum, the taeniae semicirculares, the gyrus fornicatus, the gyrus uncinatus, and the peduncles of the pineal body.

PONS VAROLII.

The Pons (bridge), variously named the bridge of Varoleus or Tuber annulare (circular protuberance), is that portion of the encephalic mass derived from the fourth cerebral vesicle, connects the hemispheres of the cerebellum, and surrounds the crura cerebri. It is a broad transverse white band of nervous tissue situated above the level of the ventral surface of the medulla, and rests upon the cranial surface of the basilar processes of the occipital and sphenoid bones, extending as high as the dorsum ephippi of the latter. It is composed of white and gray matter, and presents a superior and inferior margin, a ventral and dorsal surface.

The superior margin is rounded higher mesially than laterally,

and from its junction with the postcribrium emerges the third cranial nerves; laterally the fourth cranial nerves are superimposed.

The inferior margin is thinner than the superior, and separated from the medulla by a horizontal fissure in which are located the emergence of the sixth, seventh, and eighth cranial nerves.

The ventral surface is markedly convex, and presents a vertical groove which receives the basilar artery. Laterally to this groove are seen rounded longitudinal elevations made by the crura cerebri covered by the pons. As this ventral surface proceeds it narrows vertically and thickens horizontally to form the middle cerebellar peduncles, and from it emerge the fifth cranial nerves.

The dorsal surface is ill-defined, and forms part of the fourth ventricle, and is in contact with cerebral peduncles and still more dorsally the superior cerebellar peduncles (*processus e cerebello ad testis*). Between these latter peduncles is the upper half of the floor of the fourth ventricle, which will be described later.

On the transverse section, the pons is divided into two portions, a ventral portion and a dorsal portion. The former contains the proper transverse fibres of the pons and pyramidal fibres of the medulla continued upwards; the latter, called the *tegmentum*, is a continuation upwards of the spinal cord and the medulla with the exception of the pyramidal tracts. These transverse and longitudinal fibres each may be divided into superficial and deep fibres.

Transverse Fibres.—The superficial fibres are visible on the surface of the pons, deep transverse fibres are dorsad to the superficial longitudinal fibres, and at the lower part of the pons near the medulla a special name is given to them owing to their arrangement; it is the trapezium. Some of these transverse fibres in addition to uniting the cerebellar hemispheres act as commissural fibres, others connect nuclei in the pons.

Longitudinal Fibers.—The superficial longitudinal fibers are found to be a continuation of the anterior pyramids placed in the superficial transverse fibres of the pons. The deep longitudinal fibres are placed near the dorsal aspect of the pons, which is made up of the formatio reticularis and the prolongation of the gray matter of the medulla. Three sets of longitudinal fibres can be seen, the lemniscus or fillet, of the sensory

decussating fibres, posterior longitudinal bundles continued from the ventro-lateral column of the cord; and the fasciculus teres seen on the floor of the fourth ventricle and the fibres of the fifth nerve. The ascending roots of the fifth, fibres of the sixth, and the pars intermedia of the facial, and finally some fibres of the eighth nerves. The fasciculus teres as mentioned above being a slight network of fibres in the tegmental part of the pons ; the raphe is placed as a mesial septum continued from the median groove in the floor of the fourth ventricle with the trapezium. The gray matter of the pons consists of the pontine nucleus, the superior olivary nucleus, and the arrangement of the fifth, sixth, seventh, and eighth cranial nerves and the locus caeruleus. The nucleus ponti, or pontine nucleus situated on the ventral aspect under its transverse fibres and may be described as a number of cells which can be traced from the cerebrum and from the cerebellum. The olivary nucleus is situated behind the trapezium on the dorsal part of the pons, and corresponds to the prolongation of the lateral area of the medulla. The lucus cœruleus will be described in the floor of the fourth ventricle.

THE CEREBELLUM.

The cerebellum is that portion of the encephalon situated in the occipital fossa, beneath the posterior lobes of the cerebrum, from which it is separated by the tentorium. It measures in its transverse diameter from three and a half to four inches (8.8 to 10 cm.) ; in its antero-posterior diameter two to two and a half inches (5 to 6.3 cm.), and two inches (5 cm.) in its vertical diameter. Its form is ellipsoidal, with the long axis transverse. When the arachnoid and the pia are removed, it is noticed that its surface is darker, and not arranged in tortuous convolutions like those of the cerebrum. It is covered externally with gray matter, and consists of a multitude of thin laminæ disposed in a series of nearly parallel concentric curves, with the concavity forwards. By a little dissection it is easy to separate some of the laminæ from each other, and to see that the intervening fissures increase in depth from the centre towards the circumference.

The cerebellum consists of two lateral hemispheres united by an intermediate portion, the *vermiform process* (*the worm*), the

upper aspect of which takes the name of the *superior vermiform process*, the inferior that of the *inferior vermiform process.* Comparative anatomy proves that this is the fundamental part of the cerebellum, the lateral masses not being developed in the vertebrate series until after the birds. In man the lateral masses form by far the largest part of the cerebellum.

The two hemispheres are separated by a notch anteriorly, called the *incisura cerebelli anterior;* this notch lodges the pons. Posteriorly the hemispheres are separated by the *incisura cerebelli posterior,* which receives the falx cerebelli.

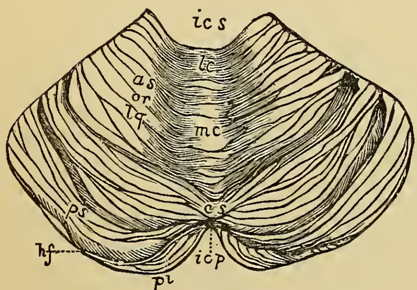


FIG. 292.—SUPERIOR SURFACE OF THE CEREBELLUM.

i c s. Incisura cerebelli anterior. *i c p.* Incisura cerebelli posterior. *a s* or *l q.* The anterior superior or quadrate lobe. *p s.* The posterior superior lobe. *p i.* The posterior inferior lobe. *h f.* The great horizontal fissure. *l c.* The lobulus centralis. *m c.* Monticulus cerebelli. *c s.* Commissura simplex.

The hemispheres are divided into a superior and inferior surface by a fissure called the great horizontal fissure. This fissure extends entirely around the cerebellum, beginning in front of the incisura cerebelli anterior and passing around the lateral margin of the hemisphere to the incisura cerebelli posterior. The fissure not only divides the hemispheres, but also the vermiform process into a superior and an inferior surface.

The SUPERIOR SURFACE of the cerebellum slopes on each side, having a ridge along the middle line called the *superior vermiform process* (superior worm). This surface is traversed by numerous small fissures or salci, extending from the great horizontal fissure of one hemisphere to a corresponding point on the opposite side, including, of course, the superior surface of the worm. These fissures are concave, with their concavity looking forward. Besides the small fissure there are four large ones; these latter divide the surface into five lobes, *i.e.*, five in each of the hemispheres and five in the superior vermiform process, the lobes of the latter lying between the two corresponding lobes of the former. They are from before backwards: the *lingula*, lying between the *two frœnula;* the *lobulus cerebralis*, on each side of which is the alæ; the *culmen*, which has on each side the *anterior crescentic lobules;* the *declive* and the posterior crescentic lobules; lastly the *folium cacumenis* and

the *posterior superior lobule,* extending backward to the great horizontal fissure.

The UNDER SURFACE of the cerebellum shows the division into the hemispheres very clearly. The deep fissure between the hemispheres is called the *volecula,* the front part of which is covered by the medulla. To examine the volecula the medulla must be removed and the hemispheres separated from each other. Along the middle line of the volecula is the *inferior vermiform process* (the inferior worm). This surface of the cerebellum is divided into lobules, just as is the superior surface. Their arrangement from behind forward is as follows: The *tuber valvule* is the most posterior of the lobes of the

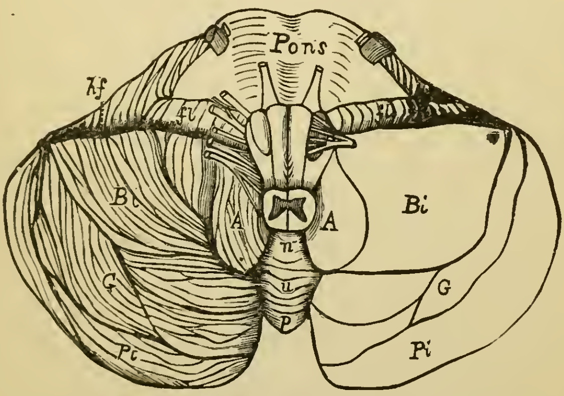


FIG. 293.—INFERIOR SURFACE OF THE CEREBELLUM.

A. The amygdala. Bi. The biventral lobe. G. The slender lobe. Pi. The posterior inferior lobe. *hf.* The great horizontal fissure. *fl.* The flocculus. *n.* The nodule situated in the vallecula. *u.* The uvula situated in the vallecula. *p.* The pyramid situated in the vallecula.

worm, and on each side is the *posterior inferior lobule;* in front of this is the *pyramid* with the *digastric lobes* on each side. Next is the *uvula,* connected on each side by the *furrowed* band with the *amygdala* (tonsil). The most anterior is the *nodulas,* on each side of which is seen the *flocculus;* passing between these is the *inferior medullary velum* or *metatela.*

At the anterior extremity of the cerebellum may be seen a mass of white matter escaping between the edges of the great horizontal fissure. If it be examined closely this will be seen to consist of a superior and an inferior layer. The inferior layer is very thin, passes dorsal to the nodule and outward to the flocculus; it is called the *inferior medullary velum.* The

anterior margin of this layer is concave, and, although apparently free, it can be traced in the epithelium covering the choroid plexus. The superior is much thicker than the inferior; the lateral extremity of this layer is much thicker than the central portion. This latter portion extends forward to the cerebrum, and is called the *valve of Vieussens* or *superior medullary velum.* At the point where the valve of Vieussens overlies the central portion of the inferior medullary velum is a cleft called the *tent*, from its pointed appearance. The tent is bounded laterally by the two amygdali. The lateral portion of this white matter, as before stated, is much thicker than the central part, and is composed of the three peduncles of the cerebellum. The cerebellum is connected with the cerebrospinal axis by the peduncles or crura, a superior, a middle, and an inferior. With medulla it is connected by means of the restiform bodies. These are called the inferior peduncles. With the cerebrum it is connected by means of the *processus e cerebello ad testes.* These are called the superior peduncles. The lateral portions of the pons contribute the middle peduncles.

Internal Structure. — To examine the internal structure of the cerebellum a longitudinal section must be made through the thickest part of one of its hemispheres. There is then seen in the centre a large nucleus of white substance, from which branches radiate into the gray substance in all directions, and upon which the gray cortical substance is deposited (laminæ).

The laminæ, about twelve in number, have branches from them at right angles, secondary laminæ; and, from these again, tertiary laminæ. This racemose arrangement of the white matter in the substance of the gray has been likened to the branches of a tree deprived of its leaves, and is generally known as the *arbor vitæ.*

Corpus Dentatum. — In the centre of the white substance of each hemisphere is a nucleus of gray matter, the corpus dentatum, consisting of a zigzag line of yellowish-gray color, incomplete at its upper and inner part, and enclosing within it some white substance. From its centre white fibres may be traced to the superior cerebellar peduncles and the valve Vieussens. It is displayed either by a vertical or by a horizontal section.

Functions. — Respecting the function of the cerebellum, the deductions derived from comparative anatomy and physiological experiments render it probable that it is the co-ordinator of muscular movements, e.g., in walking, flying, and swimming.

The encephalon is originally developed from three primary vesicles, the first and third being again divided, from which the following parts are, in the later stages, severally developed :—

1. Anterior vesicle,	Prosencephalon,	Cerebral hemispheres, corpora striata, corpus callosum, fornix, lateral ventricles, olfactory lobe.
	Thalamencephalon,	Optic thalami, pineal body, pituitary body, third ventricle, optic nerve.
2. Middle vesicle,	Mesencephalon,	Corpora quadrigemina, crura cerebri, aqueduct of Sylvius, optic nerve.
3. Posterior vesicle,	Epencephalon,	Cerebellum, pons Varolii, front part of the fourth ventricle.
	Metencephalon,	Medulla oblongata, posterior part of the fourth ventricle, auditory nerve.

The component parts of the encephalon begin to be developed at different periods of fœtal life, and the ages at which they severally begin to appear are given as follows :—

POSTERIOR VESICLE.

	Part.	*Month.*
Vetencephalon, . . .	Medulla oblongata, ...	Third
	Restiform bodies, ...	Third to fourth
	Anterior pyramids, ...	Fifth
	Olivary bodies, ...	Sixth
	Striæ acusticæ, ...	After birth
Epencephalon, . . .	Cerebellum, ...	Second, end of
	Inf. cerebellar ped., ...	Third
	Middle " "	Fourth
	Corpus dentatum, ...	Fourth
	Superior cereb. ped., ...	Fifth
	Valve of Vieussens, ...	Fifth
	Lobes of cerebellum, ...	Fifth
	Folia, ...	Sixth
	Flocculus, ...	Seventh
	Post. medullary velum, . . .	Seventh
	Amygdalæ, ...	Eighth

MIDDLE VESICLE.

Mesencephalon, . . .	Corpora quandrigemina, . . .	Fourth
	Fillet, ...	Fourth
	Corpora quadrig.:	
	Vertical groove, ...	Sixth
	Transverse, ...	Seventh

ANTERIOR VESICLE.

	Part.	Month.
Thalamencephalon, . .	Optic thalami, ...	Second to third
	Anterior commissure, ...	Third
	Posterior commissure, ...	Third, end of
	Pineal body, ...	Third to fourth
	Optic tracts, ...	Third to fourth
	Peduncles of pineal body, . .	Third to fourth
	Middle commissure, ...	Ninth ?
Prosencephalon, . . .	Island of Reil, ...	Earliest of all
	Corpara striata, ...	Third
	Corpus callosum, ...	Third, end of
	Fornix, ...	Fourth to fifth
	Sulci, primitive:	
	Fissure of Sylvius, ...	Middle of third
	Parieto-occipital, ...	Third
	Dentate, ...	Third
	Calcarine, ...	Third
	Sulci, secondary:	
	Rolando, ...	Fifth to sixth
	Parallel, ...	Fifth
	Interparietal, ...	Sixth, end of
	Calloso-marginal, ...	Sixth, end of
	Collateral, ...	Sixth, end of
	Frontal, ...	Seventh
	Hippocampus major, ...	Fourth to fifth
	Convolutions, ...	Fourth to fifth
	Convolutions develop rapidly, .	Seventh to eighth
	Septum lucidum, ...	Fifth

The cerebral hemispheres enlarge at first slowly, but later they develop much more rapidly; the extent to which they reach backwards in the various periods of intra-uterine life is as follows:—

To the optic thalami at third month,
To the corpora quadrigemina at fourth month,
To the greater part of cerebellum at sixth month,
To the posterior border of cerebellum at seventh month.

DISSECTION OF THE SPINAL CORD.

To examine, in situ, the spinal cord covered with its membranes, the arches of the vertebræ must be sawn through and removed.* It is then noticed that the cord does not occupy the whole cavity of the spinal canal. The dura does not adhere to the vertebræ, and does not form their internal periosteum, as in the skull. Between the bones and this membrane a space intervenes, which is filled with a soft reddish-looking fat, with watery cellular tissue, and the ramifications of a plexus of veins.

* A curved saw will work better than a straight one. (A. H.)

Spinal System of Veins. — The spine is remarkable for the number of large and tortuous veins which ramify about it inside and outside the vertebral canal (Fig. 294). They are: —

1. The *dorsi-spinal* or *posterior external veins*, which form a tortuous plexus outside the spinous, transverse, and articular processes, and the arches of the vertebræ; they communicate with corresponding veins above and below, and they send off branches, which pass through the ligamenta subflava and intervertebral foramina, and end in the plexus inside the vertebral canal. They join the vertebral veins in the cervical region, the intercostal in the thoracic, and the lumbar and sacral veins below.

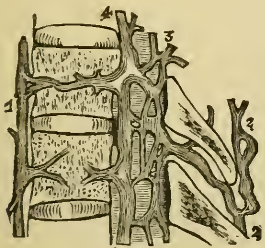


Fig. 294. — Diagram of the Spinal Veins. (Vertical Section.)

1. Anterior external veins. 2. Dorsal-spinal veins. 3. Posterior longitudinal spinal veins. 4. Anterior longitudinal spinal veins.

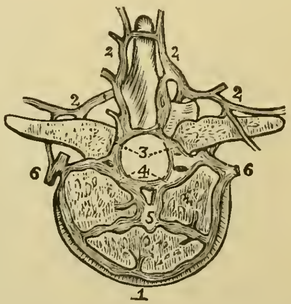


Fig. 295. — Diagram of the Spinal Veins. (Transverse Section.)

1. Anterior external veins. 2. Dorsi-spinal veins. 3. Posterior longitudinal spinal veins. 4. Anterior longitudinal spinal veins. 5. Internal veins of the body of the vertebra 6. Lateral veins.

2. The *veins of the bodies of the vertebræ* (*venæ basis vertebrarum*) emerge from the backs of the bodies, and empty themselves into the transverse vein connecting the two anterior longitudinal spinal veins.

3. The *anterior longitudinal spinal veins*, two in number, one on each side, are very large tortuous veins, which extend along the whole length of the spinal canal. They communicate by transverse branches, passing beneath the posterior common ligament, opposite the body of each vertebra, where they receive the venæ basis vertebrarum. They are larger in the thoracic and lumbar regions, and communicate externally with the vertebral, the intercostal, the lumbar, and the sacral veins.

4. The *posterior longitudinal spinal veins*, like the anterior, run along the whole length of the spinal canal. They form a

tortuous venous plexus, situated inside the vertebral arches, and communicate in front with the anterior longitudinal veins by cross branches at frequent intervals, and externally with the vertebral, intercostal, lumbar, and sacral veins by branches through the intervertebral foramina.

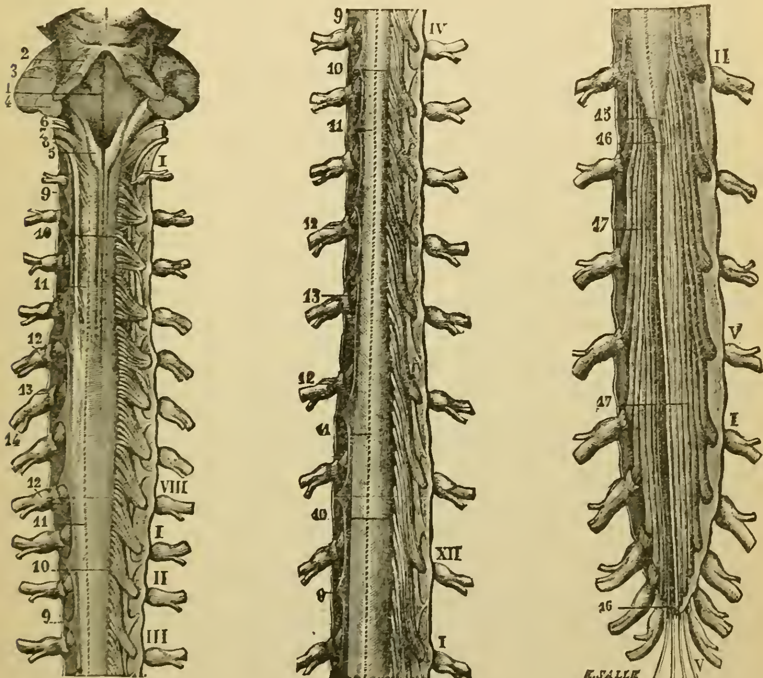
The anterior and posterior longitudinal spinal veins are situated between the spinal canal and the dura of the spinal cord, and are called the *meningo-rachidian veins.*

5. The *medulli-spinal* or *proper veins of the spinal cord* lie within the dura. They form a fine plexiform arrangement of veins over both surfaces of the cord, and can with difficulty be injected from the other spinal veins. This complicated system of veins discharges itself through the intervertebral foramina in the several regions of the spine, as follows:— In the cervical, into the vertebral veins; in the thoracic, into the intercostal veins; in the lumbar, into the lumbar veins. None are provided with valves, hence they are liable to become congested in diseases of the spine.

The membranes of the spinal cord, though the same in number and continuous with those of the brain, differ from them in certain respects, and require separate notice.

Dura.—The *dura* of the cord is a tough fibrous membrane, like that of the brain, but does not adhere to the bones, being separated from them by fat, loose areolar tissue, and the plexus of veins described above. Moreover, such adhesion would impede the free movements of the vertebræ upon each other. It is attached firmly above to the margin of the foramen magnum, and by slender tissue to the posterior common ligament, and may be traced downwards as a sheath as far as the second bone of the sacrum, from which it is prolonged as a fibrous cord to the coccyx, where it becomes continuous with the periosteum. It forms a complete canal or bag (*theca*) which surrounds loosely the spinal cord, and is relatively larger in the cervical and lumbar regions than in the thoracic. On each side are two openings in the dura for the anterior and posterior roots of the spinal nerves, and the membrane is prolonged over the trunk of each spinal nerve. These prolongations accompany the nerves only as far as the intervertebral foramina, and are there blended with the periosteum. The inner surface of the dura is covered with a layer of polygonal cells, so that it is smooth and secreting; this was formerly described as the parietal layer of the arachnoid membrane.

Cut through the nerves which proceed from the spinal chord on each side, and remove the chord with the dura entire. Then lay it flat on the table and slit up the dura along the middle of the front of the cord to examine the arachnoid membrane.



Cervical. *Dorsal.* *Inferior or Cauda equina.*

FIG. 296.—MEMBRANES OF THE CORD AND NERVES GIVEN OFF.

1. Floor of the fourth ventricle. 2. Processus e cerebello ad cerebrum or ad testes. 3. Process to the pons. 4. Process to the medulla. 5. Mammillated swelling of the posterior column. 6. Glosso-pharyngeal n. 7. Pneumogastric n. 8. Spinal portion of the spinal accessory exposed on the left side by the removal of the posterior roots of the spinal nerves. 9. Ligamentum denticulatum. 10, 10. Posterior roots of spinal nerves. 11, 11. Postero-lateral groove in which are placed these roots. 12, 12. Ganglion. 13. Anterior roots of the spinal nerves. 14. Divisions of the ganglion into two nerves. 15. Terminal extremity of the spiral cord. 16, 16. Coccygeal ligament or *filum terminale.* 17, 17. Cauda equina. The posterior cords have been removed on the left side. I, VIII. Cervical nerves. I, XII. Thoracic nerves. I, V. Lumbar nerves. I, V. Sacral nerves.

It will be seen that the functions of the dura of the cord are not identical with those of encephalon, since it does not form an internal periosteum to the bones of the spinal canal, nor does it send in partitions to support the cord, and it does not split to form venous sinuses.

Arachnoid Membrane.—The *arachnoid membrane of the cord* is a continuation from that of the brain, and is reflected over the spinal nerves as they pass from the cord to the apertures in the dura. This membrane invests the cord, and is in contact by its superficial aspect with the dura, there being an interval between them called the *sub-dural space*, although in some situations they are more or less connected by connective-tissue bands. On its deeper surface it is in contact with the pia, but is loosely connected with it by delicate areolar tissue, so that there is a considerable interval between them (*subarachnoid space*), which is occupied by a transparent watery fluid (*cerebro-spinal fluid*) contained in the meshes of the subarachnoid tissue. The separation between the arachnoid and the pia varies in different parts, and is greatest in the lower part of the cord.

Cerebro-spinal fluid.—This *cerebro spinal fluid* cannot be demonstrated unless the cord be examined very soon after death, and before the removal of the brain.* The nerves proceeding from the cord are loosely surrounded by a sheath of the arachnoid; but this only accompanies them as far as the dura, where the two are continuous.† The cerebro-spinal fluid of the cord communicates with that of the brain, and also with the general ventricular cavity through an aperture in the lower boundary of the fourth ventricle, called the *foramen of Magendie* or *metapore*.

* The existence and situation of the cerebro-spinal fluid were first discovered by Haller, *Element Phys.*. vol. iv., p. 87, and subsequently more minutely investigated by Magendie, *Recherches Phys. et Cliniques sur le Liquide Cephalo-rachidien*, in 4°, avec atlas: Paris, 1842. This physiologist has shown that if, during life the arches of the vertebræ are removed in a horse, dog, or other animal, and the dura of the cord punctured, there issue jets of a fluid which had previously made the sheath tense. The fluid communicates, through the fourth ventricle, with that in the general ventricular cavity. The collective amount of the fluid varies from 1 to 2 oz. (*29.5 to 59 c.cm.*) or more. It can be made to flow from the brain into the cord, or *vice versa*. This is proved by experiments on animals, and by that pathological condition of the spine in children termed spina bifida. In the latter instance, coughing and crying make the tumor swell, showing that fluid is forced into it from the ventricles. Again, if pressure be made on the tumor with one hand and the fontanelles of the child examined with the other, in proportion as the spinal swelling decreases, so is the brain felt to swell up, accompanied by symptoms resulting from pressure on the nervous axis generally. See some remarks very much to the point by Sir George Burrows, *On Diseases of the Cerebral Circulation*, p. 50, 1846.

† It is well to note, in operations on the vertebral column for the relief of pressure upon the cord, after the dura has been opened and no fluid is seven, that adhesions exist above that point, owing to inflammatory deposits in the arachnoid, which are easily relieved by the introduction of a probe above and below the point of operation, when the fluid appears in the wound, the arachnoid then being free. (A. H.)

Pia. — The pia of the cord is the protecting membrane which immediately invests it. It is very different in structure from that of the brain, since it does not constitute a membrane in which the arteries break up, but serves rather to support and strengthen the cord; consequently, it is much less vascular, more fibrous in its structure, and more adherent to the substance of the cord. It sends down thin folds into the ventral and dorsal median fissures of the cord, and is prolonged upon the spinal nerves, forming their investing membrane or "neurilemma."

Along the ventral median fissure may be traced a well-marked fibrous band, formed by the pia, which has been named the *linea splendens*.

Below the level of the second lumbar vertebra the pia is continued as a slender filament, called the *filum terminale*, or *central ligament*, which runs down in the middle of the bundle of nerves into which the spinal cord breaks up. About the level of the third sacral vertebra it becomes continuous with the dura of the cord, and is then prolonged as far as the base of the coccyx. The spine of the third sacral vertebra marks the level to which the cerebro-spinal fluid descends in the vertebral canal. It is supplied with nerves from the sympathetic and from the posterior roots of the spinal nerves.

Ligamentum Denticulatum. — From each side of the cord along its whole length there runs a fibrous band, *ligamentum denticulatum*, which gives off a series of processes to steady and support the cord. They are triangular, their bases being attached to the cord, and their points to the inside of the dura (Fig. 297). There are from eighteen to twenty-two of them on each side, and they lie between the anterior and posterior roots of the spinal nerves. The first process passes between the vertebral artery and the hypoglossal nerve; the last is found at the termination of the cord. It is composed of fibrous tissue, and is covered with nucleated cells continuous with the arachnoid membrane.*

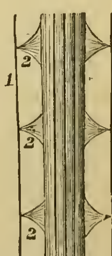


FIG. 297. — DIAGRAM OF THE LIGAMENTUM DENTICULATUM.

1. Dura mater. 2, 2, 2. Ligamentum denticulatum.

* *Vide* Axel Key and Retzius; Max Schultz's *Archives*, 1873.

SPINAL CORD.

The *spinal cord* (medulla spinalis) is that part of the cerebrospinal axis contained in the vertebral canal, and is enclosed within a sheath of dura (*theca vertebrates*), which is separated from the canal by a plexus of veins and connective tissue. It is the continuation of the medulla oblongata, and extends from the foramen magnum down to the lower border of the first lumbar vertebra, where it terminates in a conical point, *conus medullaris,* after having given off a large bundle of nerves, termed the *cauda equinæ,* for the supply of the lower limbs.

It is from fifteen to eighteen inches (*37.5 to 40 cm.*) in length, and is about an ounce and a half (*43 grm.*) in weight. Its lower extremity from the conus medullaris is continued downwards as a thin silvery cord, the *filum terminale* which descends along the posterior aspect of the cauda equina. It passes down within the sheath as far as the second sacral vertebra, and then, piercing the dura, becomes attached to the periosteum of the canal at the back of the coccyx.* In its upper part, the filum terminale contains some gray nerve-substance. It is a prolongation of the pia of the cord, and in many subjects there is a continuation of the central canal of the cord in its upper half.

The cord is not of uniform dimensions throughout. It presents a considerable enlargement in the lower part of the cervical region (Fig. 296, p. 761); another in the lower part of the thoracic, from which proceed the large nerves to the upper and lower limbs, respectively. The upper or cervical enlargement, which is the larger, extends from the third cervical to the first thoracic vertebra, and is largest at the sixth cervical vertebra; the lower, or lumbar, extends from the twelfth thoracic vertebra and is largest opposite the last thoracic vertebra.†

The cord is divided into two symmetrical halves by a median longitudinal fissure in front and behind (Fig. 298). The *anterior* or *ventral fissure* is the more distinct and wider, and penetrates

* The explanation of this is, that, at an early period of fœtal life the length of the cord corresponds with that of the vertebral canal; but after the third month the lumbar and sacral vertebræ grow away from the cord, in accordance with the more active development of the lower limbs. See Tiedemann, *Anatomie und Bildungsgeschichte des Gehirns im Fœtus des Menschen*, &c., Nüremberg, 1816.

† In very early fœtal life these enlargements do not exist, and only make their appearance with the development of the extremities.

about one-third of the substance of the cord; deeper in the lower than in the upper part of the cord. It contains a fold of pia, with many blood-vessels for the supply of its interior. At the bottom of this fissure is a transverse layer of white substance, named the anterior white commissure, connecting the two anterior halves of the cord. The *posterior* or *dorsal fissure* is much less apparent than the anterior, and is better marked in the upper and the lower parts of the cord. It does not contain a fold of pia, but contains a thin septum of connective tissue with blood-vessels. It can be traced to a greater depth than the anterior, and reaches down as far as the *posterior gray commissure* of the cord.

Running along the centre of the cord in its whole length is a minute canal, the *central canal*, just visible to the naked eye. Below, in the conus medullaris, it ends in a dilated cul-de-sac, of

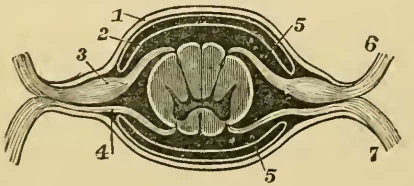


FIG. 298. — DIAGRAM OF A TRANSVERSE SECTION THROUGH THE SPINAL CORD AND ITS MEMBRANES.

1. Dura. 2. Arachnoid membrane. 3. Ganglion on posterior root of spinal nerve. 4. Anterior root of spinal nerve. 5, 5. Seat of sub-arachnoid fluid. 6. Posterior branch of spinal nerve. 7. Anterior branch of spinal nerve.

the shape of the letter T; above it opens out at the calamus scriptorius into the fourth ventricle. It is lined with cylindrical ciliated epithelium. This central canal is interesting, as it is the remains of the cavity formed by the spinal cord at the earliest period of its development.*

Spinal Nerves. — Thirty-one pairs of nerves arise from the spinal cord, namely, eight in the cervical region, twelve in the thoracic, five in the lumbar, five in the sacral, and one in the coccygeal. Each nerve is formed by the junction of two series of roots, one from the front, which is the *motor root*, the other from the back of the cord, which is the *sensory* and *larger root*. The two roots pierce the dura separately and then converge to the corresponding intervertebral foramen to form a single nerve, composed of motor and sensory filaments.

* The central canal is well seen in fishes, birds, and reptiles.

The filaments composing the *posterior roots* are finer, but their fasciculi are thicker and more numerous than the anterior.* They proceed from the postero-lateral fissure, and previous to their union with the anterior roots are collected into two bundles which pass through a ganglion. The *ganglion* is of an oval form, bilobate on its external extremity, and lies in the intervertebral foramen; each fasciculus of the posterior root enters the corresponding lobe of the ganglion. The ganglia of the first and second cervical nerves are placed upon the arches of the atlas and axis respectively; the ganglia of the sacral and coccygeal nerves are situated within the spinal canal. The *anterior roots* arise from the antero-lateral column, are smaller than the posterior roots, but like them divide into two fasciculi as they approach the ganglion on the posterior root.

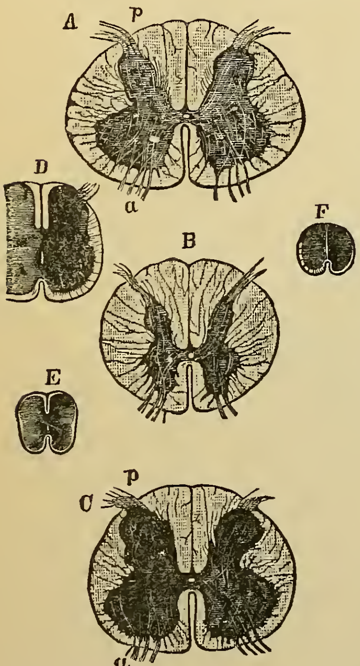


Fig. 299.—Transverse Sections of the Spinal Cord in Different Regions.

A. Through the middle of the cervical. B. The thoracic. C. The lumbar enlargement. D. Upper part of the conus medullaris. E. At the 5th sacral vertebra. F. At coccyx. A, B, C. Enlarged twice. D, E, F. Thrice. *a*. Anterior. *p*. Posterior root.

The compound nerve formed by the junction of the two roots, external to the ganglion of the posterior, divides, outside the intervertebral foramen, into an anterior (ventral) and posterior (dorsal) branch (Fig. 298, p. 765).

The fibres of the anterior roots, after entering the antero-lateral column, pass through the white fibres to enter the gray matter; here they pass in all directions, the larger number passing upwards and downwards, and some decussating with corresponding filaments of the opposite side, through the anterior white commissure; some also pass upward vertically through the lateral column. The fibres of the posterior roots enter the caput cornu posterioris through

* This does not apply to the first cervical nerve, in which the anterior root exceeds the posterior in size.

the postero-lateral groove, and then pass upwards and downwards in the gray matter, chiefly of the posterior horn; but some curve round to enter the anterior horn, while others pass to the opposite side through the posterior gray commissure.

Variation in the Length of the Roots. — The direction and length of the roots of the nerves vary in the different regions of the spine, owing to the respective parts of the cord from which they arise not being opposite to the foramina through which the nerves leave the spinal canal (Fig. 296, p. 761). In the upper part of the cervical region the origins of the nerves and their point of exit are nearly on the same level; therefore the roots proceed transversely, and are very short. Lower down, however, the obliquity and length of the roots gradually increase, so that the roots of the lower thoracic nerves are at least a vertebra higher than the foramina through which they emerge. Again, since the cord itself terminates at the lower border of the first lumbar vertebra, the lumbar and sacral nerves must descend from it almost perpendicularly through the lower part of the spinal canal.

Cauda Equina. — To this bundle of nerves the old anatomists have given the name of *cauda equina,* from its resemblance to a horse's tail.

To sum up briefly, it appears that the spinal cord consists of two symmetrical halves, separated in front and behind by a deep median fissure; that the two halves are connected at the bottom of the anterior fissure by an anterior or white commissure, at the bottom of the posterior fissure by the posterior or gray commissure; that each half of the cord is divided into three tracts or columns of longitudinal white nerve-fibres — anterior or ventral, lateral and posterior or dorsal columns (each is again divided into tracts as will be seen later) — the boundaries between them being the respective lines of origin of the roots of the spinal nerves; that the interior of the cord contains gray matter disposed in the form of two crescents, placed with their convexities towards each other, and connected by a transverse bar of gray matter, which constitutes the posterior commissure.

Blood-vessels of the Cord. — The cord is supplied with blood by — 1. The *anterior spinal* artery, which commences at the medulla oblongata by a branch from the vertebral of each side, and then runs down the middle of the front of the cord. Other branches are derived from the vertebral, ascending cer-

vical, intercostal, and lumbar arteries, which pass through the intervertebral foramina, and assist in keeping up the size of this anterior artery. 2. The *posterior spinal* arteries, which proceed also from the vertebral, intercostal, and lumbar arteries, and ramify somewhat irregularly on the back of the cord.

On the posterior part of the bodies of the vertebræ, the spinal arteries of opposite sides communicate by numerous transverse branches along the entire length of the spine, thus resembling the arrangement of its venous plexuses.

Functions of the Spinal Cord. — The spinal cord performs, at least, three functions: — 1. It is the general conductor of impressions to and from the brain. 2. It transfers impressions. 3. It is a centre of reflex action. *Sensory* impressions are conducted by the posterior roots of the spinal nerves to the cord, and are thence transmitted to the brain through the posterior columns and the gray matter of the cord. These impressions do not run up on the same side, for the fibres, immediately on entering the gray matter, cross over to the opposite side to reach the brain; so that if the posterior column of the *right* side be divided, the *left* leg, and not the right, would be deprived of sensation. *Motor* impulses are conveyed along the antero-lateral columns and the gray matter in them, and carry the commands of the will from the brain to the muscles. The crossing of the motor fibres takes place in the medulla oblongata, at the decussation of the anterior pyramids, so that they run in the corresponding half of the cord as far as their point of decussation. Division, therefore, of one-half of the cord below this point, causes paralysis of motion on the same side of the body. The cord is, moreover, concerned in the conduction of impressions to and from the *vaso-motor centre* of the medulla oblongata, which determines the varying conditions of the blood-vessels. The cord also transfers impressions: this is more manifest in disease than in health; a well-marked example of transference is, that pain is felt at the knee in cases of disease of the hip-joint. The spinal cord has probably no power of originating impressions, in other words, it is *not automatic.*

Besides the anterior and posterior fissures is another superficial lateral groove, from which the posterior roots of the spinal nerves emerge; this is termed the posterior lateral groove. This leads down to the posterior horn of the gray matter in the interior of the cord. There is sometimes described an antero-

lateral groove, corresponding to the line whence the anterior roots of the spinal nerve emerge; but this is not really a groove. On each side of the posterior median fissure, between which and the posterio-lateral fissure is a slight groove ; this is best seen in the cervical region, but is said by Foville to be present along the whole length of the cord. These fissures seem to map out each half of the cord into three longitudinal portions. An antero-lateral column, between the antero-median fissure and the posterior lateral fissure ; a postero-lateral column, which lies between the postero-lateral fissure and the slight groove spoken of above; the postero-median column, which is just external to the postero-median fissure.

These columns all pass into the medulla, where they have been described.

Internal Structure. — A transverse section through the cord shows that, externally, it is composed of white nerve substance, and that its interior contains gray matter arranged in the form of two crescents with their backs to each other.

The white substance is made up of nerve fibres, blood-vessels, and neuroglia. The nerve fibres are of three kinds, — longitudinal, transverse, and oblique. The longitudinal fibres constitute the principal portion of the columns spoken of above, and pathological investigation has shown these columns to be subdivided into eight tracts, namely, the direct pyramidal tracts, the antero-lateral ground bundle, the crossed pyramidal tract, the antero-lateral descending and ascending cerebelli tract, the tract of Lissauer, the postero-lateral or Burdach's column, and the postero-median or Goll's column. The transverse and oblique fibres are principally found in the anterior commissure, passing from the anterior cornu to the white matter in the anterior column of the opposite side.

Each crescent is placed in its corresponding half of the cord, and is connected with its fellow across the centre by a portion called the *posterior or gray commissure.* The posterior horns are long and narrow, and extend to the posterior lateral groove, where they are connected with the posterior roots of the spinal nerves. At their extremities they taper to a point, the *apex cornu posterioris ;* and near their bases they present a constriction, the *cervix cornu,* beyond which they slightly enlarge to form the *caput cornu.* The outline of the gray matter of the posterior horns at their commencement is indefinite and frayed out, which is especially noticeable in the cervical region and is

called the *processus reticularis ;* at their apices the gray matter is semi-transparent in appearance, and hence is known as the *substantia gelatinosa.* In the centre of the concavity of the posterior horn is a rounded projection, most marked in the upper thoracic region, termed the *tractus intermedia lateralis,* the continuation of which has been traced upwards through the medulla. On the inner side of the base of the posterior horn is a column of cells known as *Clark's vesicular column ;* this column extends from the origin of the seventh or eighth cervical nerves to the third lumbar. The anterior horns are short and thick, and curve forward towards the attachments of the anterior roots of the nerves, but do not reach the surface. Separating the gray commissure from the anterior median fissure is the *anterior or white commissure.*

On making transverse sections through different regions of the spinal cord, the gray substance is seen to vary in shape and amount. In the cervical region the anterior cornua are thick and short ; the posterior are long and slender. In the thoracic the anterior and posterior cornua are both thin. In the lumbar the anterior and posterior cornua are large and broad. In the lower part of the cord the gray matter is arranged in a central mass.

DISSECTION OF THE EYE.

Since the eye in the human subject cannot be obtained sufficiently fresh for anatomical purposes, the student should examine the eye of the sheep, bullock, or pig. The conjunctiva should be removed, together with the loose connective tissue which unites it to the sclerotic coat.

Conjunctiva. — The *conjunctiva* is the mucous membrane which covers the ocular surface of the eyelids and the anterior part of the globe. It presents different characters in the various situations over which it is reflected, and is described as the palpebral, the sclerotic, and the corneal portions.

The *palpebral portion* is thicker than the other portions, is very vascular, and is provided with fine papillæ abundantly supplied with nerves. As described, p. 47, it is continuous with the mucous membrane of the lachrymal sac through the canaliculi, and lines the Meibomian glands and the ducts of the lachrymal gland. The columnar epithelium which lines the palpebral conjunctiva becomes at the margins of the eyelids more stratified and continuous with the flattened cells of the skin of the eyelid. It forms at the inner canthus a reduplicated fold, the *plica semilunaris*, and is reflected from the eyelids of the globe, its angle of reflection being called the *fornix conjunctivæ* and the folds into which this is thrown are termed the *superior* and *inferior palpebral folds*.

The *sclerotic conjunctiva* is loosely attached by submucous tissue to the sclerotic coat, so as not to impede the movements of the globe. It is thinner, and has no papillæ. It is transparent and nearly colorless, except when inflamed; it then becomes intensely vascular, and of a bright scarlet color. The arteries are derived from the lachrymal and palpebral branches of the ophthalmic artery, and at the circumference of the cornea they form capillary loops which anastomose with each other. The lymphatics are well marked in the palpebral and sclerotic portions of the conjunctiva, and at the margin of the cornea they rapidly diminish in size and become connected with the cell-spaces in the cornea. An abundant supply of nerves is distributed to the membrane; their arrangement is in the form

of plexuses as far as the margin of the cornea, where they terminate in "end-bulbs," described by Krause, resembling in many respects the central portion of Pacinian corpuscles.

The *corneal conjunctiva* is composed chiefly of epithelium arranged in layers, the deepest of which consists of columnar cells resting by their bases on the substantia propria of the cornea; superficial to these are two or three layers of polygonal cells, the deepest of which, called the *fingered cells of Cleland*, interdigitate with the columnar cells; and on the surface there is a layer of flattened squamous epithelial cells. This portion of the conjunctiva cannot be separated by dissection in recent eyes, but it possesses the same acute sensibility as the rest of the conjunctiva. Changes produced by inflammation of the conjunctiva often involve the cornea and render its texture thick and opaque.*

The eyeball is embedded in a large quantity of fat and delicate connective tissue; and surrounding it in its posterior three-fourths is a serous membrane, the *capsule of Tenon*, which allows of its free movement in the orbit.

The axes of the two eyeballs are nearly parallel with each other; thus they do not correspond with the axes of the orbits, nor of the optic nerves which enter the globes on their nasal aspect.

The human eye is nearly spherical and consists of segments of two spheres: a large posterior one, which corresponds with the sclerotic, and a small anterior one with the cornea. The antero-posterior diameter taken from the anterior corneal surface to the posterior sclerotic surface averages a little less than an inch, or accurately 24.27 mm.; the inner measurement taken from the inner surfaces of the above membranes 21.74 mm. The vertical diameter less than an inch by $\frac{1}{12}$ or 23.65 mm. The optic nerve enters about $\frac{1}{8}$ of an inch (3 *mm.*) to inside of the antero-posterior axis. The weight is 108½ grains or 7.2 grm. The volume 6 c.cm., and the specific gravity 1.025. The antero-posterior diameter varies considerably up to the 21st year; is less in the female. This fact accounts for the varying degrees of near and far sight. The cornea is thicker in the child in the centre, but as age advances this decreases.

* The facts of comparative anatomy confirm this view. In the serpent tribe, which annually shed the skin, the front of the cornea comes off with the rest of the external surface of the body. In the eel the surface of the cornea is often drawn off in the process of skinning. In some species of rodents which burrow under the ground like the mole, the eye is covered with hair, like other parts.

Coats and Humors of the Eye.—The globe is composed of three concentric coats, arranged one within the other, which enclose certain transparent structures for the transmission of light. The external coat, consisting of the *sclerotic* and *cornea*, is fibrous, thick, and strong. The second coat, consisting of the *choroid*, the *iris*, and the *ciliary processes*, is composed of blood-vessels, muscular tissue, and pigment cells, and is very dark in color. The third coat, called the *retina*, consists of the expansion of the optic nerve for the reception of the impression of the waves of light. The bulk of the interior is filled with a transparent humor, called the *vitreous body*. Embedded in the front of this, and just behind the pupil, is the crystalline lens, for the purpose of concentrating the rays of light. In front of the lens is placed a movable curtain, called the *iris*, to regulate the amount of light which shall be admitted through a central aperture, the *pupil*, to the fundus of the eye. The space in which the iris is suspended is filled with a fluid, termed the *aqueous humor*.

Sclerotic Coat.—The *sclerotic coat* is the white tough protecting coat of the eye which serves to maintain the form of the globe.* It covers the posterior five-sixths of the globe, the remaining anterior one-sixth being completed by the cornea. It is of dense white color, except in front, where the tendons of the recti and obliqui are inserted into it. The thickest part of the sclerotic coat is at the back of the globe (Fig. 301); the thinnest is a short distance behind the cornea.† The back of the sclerotic is perforated by the optic nerve, which enters it about one-eighth of an inch (*3 mm.*) on the inner or nasal side of the axis of vision. The sheath of the optic nerve becomes continuous with the sclerotic, where it perforates this coat. The optic nerve at its entrance into the sclerotic is much constricted, and instead of passing through a single aperture in this coat, it enters it through a number of minute apertures, so that this membrane forms a porous lamina, called the *lamina cribrosa*. In the centre of the lamina cribrosa is an opening (*porus opticus*), larger than the rest, which transmits the arteria

* The sclerotic coat of the eye in fishes is of extraordinary thickness and density; and in birds this coat is further strengthened by a circle of bony plates, fourteen or fifteen in number, arranged in a series round the margin of the cornea. Similar plates are found in some of the reptiles, and particularly in the fossil ichthyosauri and plesiosauri.

† The greatest thickness posteriorly is about the $\frac{1}{25}$ of an inch (*1 mm.*); its thinnest in front is about the $\frac{1}{50}$ of an inch (*.5 mm.*).

centralis retinæ. Around the optic nerve the sclerotic is pierced by the ciliary arteries, veins, and nerves, for the supply of the choroid and iris. About a quarter of an inch (*6 mm.*) from the cornea the sclerotic receives the insertions of the recti muscles; * here also it transmits the anterior ciliary arteries, which run forward along the tendons of these muscles, and form a vascular ring around the circumference of the cornea (Fig. 300).

Structure. — The sclerotic is composed of connective tissue arranged in bundles, which run, some longitudinally, some transversely, and are intermingled with fine elastic fibres. The longitudinal fibres are the most external and abundant. Under the microscope numerous connective-tissue corpuscles may be seen filling cell-spaces, similar to those in the cornea but not so abundant, and containing pigment-granules. The inner surface of the sclerotic is of a dark brownish color, due to the presence of a thin layer of connective tissue, *lamina fusca*, in which are found pigment-cells. This surface of the sclerotic is grooved for the passage of the ciliary nerves, which run forward in a sort of lymph-space; and it is, moreover, connected by filamentous tissue with the subjacent choroid.

Cornea. — The *cornea* is the brilliant translucent coat which forms about one-sixth of the globe. It is nearly circular in shape, its diameter being nearly half an inch, or accurately (*11.5 mm.*), and its thickness about $\frac{1}{25}$th of an inch (*1.12 mm.*). The curve of the cornea forms part of a smaller circle than that of the sclerotic, so that it projects further forwards, varying in this respect in different eyes, and at different ages of life. It is firmly connected at its margin to the sclerotic, with the fibres of which it is continuous. The margin of the sclerotic is bevelled on the inside; that of the cornea on the outside, so that the former overlaps the latter (Fig. 301).

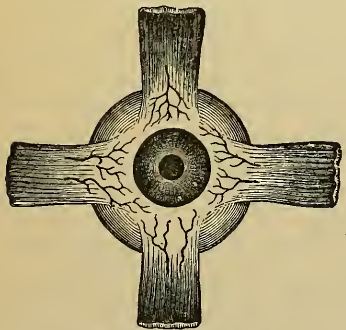


Fig. 300. — Insertion of the Recti Muscles with Anterior Ciliary Arteries.

To examine the cornea, it should be removed with the sclerotic coat. This should be done under water, by making a circular

* There is, however, some variation, the internal rectus being nearest to the cornea; the other tendon about (*1 mm.*) $\frac{1}{25}$ of an inch farther back. (A. H.)

cut with the scissors, about a quarter of an inch (*6 mm.*) from the margin of the cornea. With a little care it will be easy to remove the outer coat of the eye without injuring the dark choroid coat, the ciliary muscle, or the iris. In the loose brown-colored connective tissue between the sclerotic and the choroid are the ciliary nerves passing forwards to the iris; their white color makes them very conspicuous on the dark ground.

Structure. — The cornea consists of four layers, which are not all composed of the same kind of tissue; they are, from without inwards, the conjunctiva, the substantia propria or cornea proper, the posterior elastic lamina, and the epithelial lining.

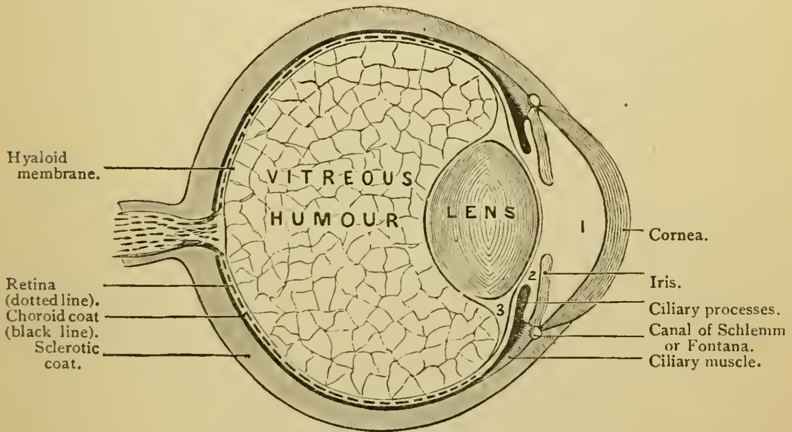


FIG. 301.— DIAGRAM OF A VERTICAL SECTION OF THE EYE

1. Anterior chamber filled with aqueous humour. 2 Posterior chamber. 3. Canal of Petit.

The *conjunctiva* is the most superficial layer, and consists of several strata of epithelial cells: the deeper ones are columnar and placed vertically, the next consist of several layers of polygonal cells, and the most superficial ones are flattened scaly epithelium cells, with well-marked nuclei.

The *cornea proper* or *substantia propria* consists of translucent connective tissue, upon which the thickness and strength of the cornea mainly depend. The fibres are arranged in laminæ, about sixty in number. Those composing a lamina are arranged in a parallel direction, but the fibres of each layer cross at right angles those of each succeeding layer. The lamellæ are connected together by filaments passing from one to another, so

that they are not perfectly separate from each other. The cornea proper in the recent subject presents no trace of structure, but it is only after death by means of lenses and reagents that these lamellæ can be satisfactorily demonstrated. Between

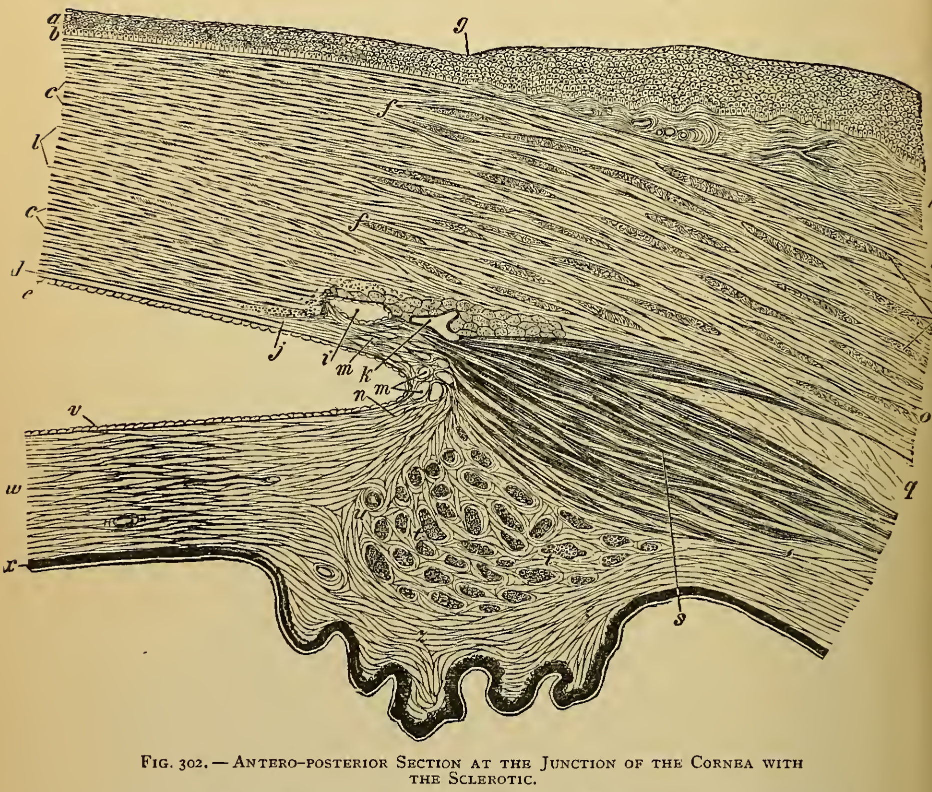


FIG. 302.—ANTERO-POSTERIOR SECTION AT THE JUNCTION OF THE CORNEA WITH THE SCLEROTIC.

a. Anterior corneal epithelium. *b.* Bowman's lamina. *c.* Corneal corpuscles. *l.* Corneal lamellæ (the whole thickness lying between *b* and *d* is the substantia propria). *d.* Descemet's membrane. *e.* Its epithelium. *f.* Junction of cornea with the sclerotic. *g.* Limbus conjunctivæ. *h.* Conjunctiva. *i.* Canal of Schlemm. *k.* Leber's venous plexus (is regarded by Leber as belonging to *i*). *m. m.* Meshes in the tissue of the lig. iridis pectinatum. *n.* Attachment of the iris. *o.* Longitudinal, *p.* Circular (divided transversely) bundles of fibres of the sclerotic. *q.* Perichoroidal space. *s.* Meridional (radiating). *t.* Equatorial (circular) bundles of the ciliary muscle. *u.* Transverse section of the ciliary artery. *v.* Epithelium of the iris (a continuation of that on the posterior surface of the cornea). *w.* Substance of the iris. *x.* Pigment of the iris. *z.* A ciliary process.

the lamellæ are irregularly branched spaces, called the *cell-spaces of the cornea*, in which are lodged the *corneal corpuscles*, having outstanding processes, which communicate freely with each other in their own plane, and also with those of the planes

on either side. These corpuscles correspond in shape to the spaces within which they lie.* In inflammation of the cornea they undergo considerable changes. Immediately below the conjunctiva, the cornea proper presents a different appearance to that of the main thickness of this layer, so that this has been described by some anatomists under the name of the *anterior elastic lamina* of Bowman. It presents, however, a definite fibrillar structure, similar to that of the cornea proper, but is destitute of the corneal corpuscles and cells. The greatest thickness of the cornea proper is about $\frac{1}{25}$th of an inch (*1.12 mm.*).

The *posterior elastic lamina*, called also the *membrane of Descemet* or *Demours*, is translucent, elastic, and brittle, and may be easily separated from the preceding lamina. It consists of a perfectly structureless lamina, which, when peeled off, has a remarkable tendency to curl with the attached surface innermost. At the junction of this lamina with the sclerotic on its inner surface, it spreads out into a number of radiating tooth-like processes, the *ligamentum pectinatum iridis*, which was attached to the front of the circumference of the iris and to the sclerotic and choroid coats. The processes alone are covered with epithelial cells, and the intervals between the processes form small spaces, the *spaces of Fontana*, which communicate freely with the fluid of the aqueous chamber. In the sclerotic coat, close to its junction with the cornea, is situated a small oval canal, lined with epithelium, termed the *sinus circularis iridis* or *canal of Schlemm* (Fig. 302). Although, by some, it is considered a lymph-space, it is probably a venous sinus, for it can be injected from the arteries; but it has probably some free communication with the fluid of the anterior chamber, as this fluid passes rapidly from the chamber into this sinus.†

The *epithelial lining* consists of a single layer of polygonal nucleated cells, and lines the inner surface of the posterior elastic lamina. They resemble those which line serous membranes generally.

* If fluid be injected very gently into the cornea proper, there may be demonstrated a system of canals, called *Rechlinghausen's canals*, which are the communications between the corneal corpuscles; but if the fluid be injected more forcibly, it passes in the course of the fibres composing the various laminæ of the cornea, which gives the appearance of a number of varicose and enlarged tubes crossing each other at right angles; these are termed *Bowman's corneal tubes*.

† For further information on this point consult Leber, *Archiv f. Opth.* 1878; Heisrath, *Archiv f. Opth.* XXVI.; and Schwalbe, Graefe, and Saemisch's *Handbook*, 1874.

Arteries and nerves. — In the healthy condition the cornea contains no blood-vessels, except at its circumference, where they form loops. Nor have any *lymphatics* been demonstrated in it. Its *nerves*, which are numerous — forty to forty-five in number — are derived from the ciliary nerves, and may be traced forwards to the fibrous portion of the cornea, where they lose their dark outline and become transparent, forming a fine plexus — the *primary plexus.* This gives off minute filaments which ramify beneath the epithelium, constituting the *secondary* or *sub-epithelial plexus.* From this very minute varicose fibres run between the epithelial cells, forming the *intra-epithelial plexus.* Besides these plexuses, filaments are given off from the primary plexus to supply the cornea proper, and the filaments are said by some to be continuous with the anastomosing processes of the cell-spaces.

Choroid Coat. — After the removal of the sclerotic coat and the cornea, which constitute the first tunic, we expose the second tunic, consisting of the choroid, the iris, and ciliary processes in front, and of the ciliary ligament and the ciliary muscle.

The *choroid* is the soft and flocculent tunic of the eye, recognized by its dark brown color and great vascularity. It covers the posterior five-sixths of the globe, and is thickest posteriorly, where there is a circular aperture in it for the passage of the optic nerve. In front, the choroid passes beneath the ciliary muscle and ligament with which it is connected, and then extends forwards, terminating in a series of plaited folds, called the *ciliary processes.* It is connected with the sclerotic by delicate connective tissue, the *lamina fusca*, through which the ciliary vessels and nerves pass forwards (Fig. 303) to the iris. Its inner surface is smooth, and is in contact with the retina, and when detached from it presents a layer of hexagonal pigmented cells, which are now recognized as forming a part of the retinal coat and as part of which it is originally developed.

Stucture. — Under the microscope the choroid is seen to consist of two layers, an external and an internal. The choroid is covered externally by a connective tissue layer, similar to the lamina fusca of the sclerotic, and known as the *lamina supra-choroidea;* it consists of connective tissue intermingled with elastic tissue, and embedded in the meshwork are pigment cells and lymphoid cells. The contiguous surfaces of the lamina fusca and the lamina supra-choroidea are lined with squamous

epithelium, having between them a more or less complete lymph-space, which is continuous with that of Tenon's capsule through the apertures in the sclerotic, through which the ciliary vessels and nerves pass.

The *external layer* consists of the larger branches of the blood-vessels; the arteries (short ciliary) running forwards between the veins, previous to dipping down to form the internal layer. The veins are arranged with great regularity in drooping branches (*venæ vorticosæ*) like the weeping willow (Fig. 303), and converge to four or five nearly equidistant trunks, which, after running backwards for a short distance, perforate the sclerotic not far from the entrance of the optic nerve, and empty themselves into the ophthalmic vein. Between the veins there are interspersed numerous stellate pigment-cells which anastomose with neighbouring cells; on the inner side of this layer the cells are absent.

The *internal layer* is formed by the capillaries of the ciliary arteries and is called the *tunica Ruyschiana*, after the Dutch anatomist Ruysch. The capillaries branch off from the choroid vessels in a radiating manner, and form the most delicate vascular network found in any tissue. It extends forward as far as the retina, where the intervals become larger and the vessels freely communicate with those of the ciliary processes. This tissue has on its inner surface a transparent membrane, the *membrane of Bruch*, which rests on the pigmentary layer of the retina.

Ciliary Processes. — The *ciliary processes* are the plaited folds formed by the anterior part of the choroid, and may be best seen when the globe has been divided by a transverse vertical section into an anterior and a posterior half, the vitreous humor being left undisturbed. They are black, and consist of from sixty to seventy radiating folds arranged in a circle. These processes consist of longer and shorter folds, the former being the more numerous, and in the proportion of three to one of the latter. The processes fit into corresponding folds of the suspensory ligament of the lens, and their free ends project for a short distance into the posterior chamber. The circumference of the processes are attached to the ciliary ligament; their inner ends are free and rest upon the circumference of the lens.

Structure. — The vascular supply of the ciliary processes is most abundant and resembles in the main that of the choroid, except that the plexus is coarser, with its meshes arranged

longitudinally. The *arteries* come chiefly from the anterior ciliary, and from the front vessels of the choroid; and after breaking up into a fine plexus, they form loops which arch backwards, to end in the smaller veins. Their dark color is due to several layers of pigmented cells, which disappear, however, at the free ends of the processes.

Ciliary Muscle. — The *ciliary muscle* consists of unstriped muscular fibres, and forms a muscular zone at the front of the choroid (Fig. 302), close to the junction of the sclerotic with the cornea. It arises by a thin tendon from the sclerotic close to the cornea, and near the spaces of Fontana. Thence some of its fibres radiate backwards, forming the *meridional* or *radiating fibres,* and are lost in the choroid behind the ciliary processes: some of the fibres form a circular muscle around the outer circumference of the iris, the *circular ciliary muscle,* which was formerly described as the ciliary ligament. Its action is to accommodate the eye to objects at various distances by compressing the lens and increasing the convexity of its anterior surface.*

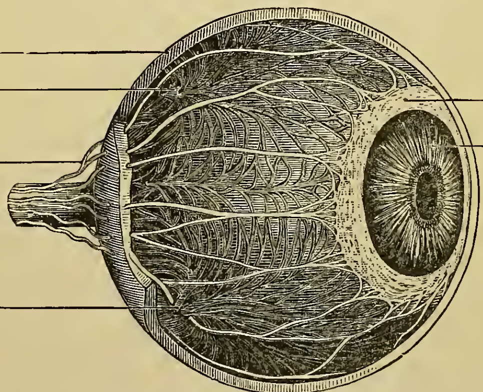


FIG. 303. — SCLEROTIC COAT REMOVED TO SHOW THE CHOROID, CILIARY MUSCLE, AND NERVES.

Iris. — The *iris* is the contractile and colored curtain suspended in the clear fluid which fills the space between the cornea and the lens. The iris divides this space into two unequal parts, called the *anterior* and *posterior chambers* (Fig.

* Sir P. Crampton has noticed that this muscle is well developed in birds. In them, its muscles are of the striped variety, as are the circular fibres of the iris.

301); these communicate with each other through a circular aperture in the centre of the iris, called the *pupil*, which is situated a little to the inner side of the iris.*

The circumference of the iris is nearly circular, and is immovably connected with the choroid, the ciliary muscle, and through the ligamentum pectinatum with the cornea. The diameter of the iris is about half an inch (*13 mm.*), and that of the pupil in man varies from the $\frac{1}{20}$th (*1.2 mm.*), to the $\frac{1}{3}$rd of an inch (*8 mm.*).

The color of the iris varies in different subjects, and gives the peculiar tint and brilliancy to the eye. The coloring matter or pigment is contained in minute cells, *pigment cells*, lining the anterior and posterior surfaces of the iris, the posterior taking the name of *uvea*, from its grape-like color. Pigmented cells are also found in the substance of the iris.

The use of the iris is to regulate the amount of light which shall be admitted into the eye; for this purpose its inner circumference is capable of dilating and contracting according to circumstances, while its outer circumference is immovably attached.

Structure. — When the iris is laid under water, and viewed with a low magnifying power, it is seen to be composed of fine fibres converging from all sides towards the pupil; many of them unite and form arches, leaving elongated interspaces, which are most marked towards the middle of the iris.

In front of the iris is a thin layer of polyhedral cells, which is continuous with that covering the membrane of Descemet, but the cells are smaller and more granular.

The *stroma* consists of connective tissue and cells. The fibres of the connective tissue are arranged longitudinally and circularly; the longitudinal fibres radiate from the circumference towards the pupil, and between them are contained the blood-vessels and nerves; the circular fibres are found at the circumference of the iris. Intermingled in the meshes of this connective tissue and throughout its whole thickness are numerous and various-shaped pigment cells having anastomosing processes, like those of the choroid. They are chiefly found in the uvea, which is continuous with the pigmented layer of the retina. Upon the disposition of these pigment-

* The size and shape of the pupil vary in different animals. In the bullock, sheep, horse, etc., it is oblong; in carnivorous quadrupeds it is often a mere vertical slit during the day, but dilates into a large circle at night.

cells depends the color of the iris: in dark eyes, the pigment-cells are scattered throughout the thickness of the stroma; in light eyes, only on its posterior surface.

The *muscular tissue* is of the unstriped kind, and is arranged partly in a radiating, partly in a circular manner. The circular fibres, the *sphincter*, well marked, are collected on the posterior aspect of the pupillary margin, where they form a ring about $\frac{1}{40}$th of an inch (*.5 mm.*) in width; at the free margin of the iris they form a thick bundle, but become more frayed out towards the circumference.* The radiating fibres, the *dilatator*, converge towards the pupil, where they form arches and blend with the circular fibres.

The *pigment*, as before described, is found in varying thickness and position, differing according to the color of the iris.

The *arteries* of the iris are derived from the two long and the anterior ciliary arteries. The *long ciliary arteries* (Fig. 304) perforate the sclerotic coat on each side of the optic nerve, and then run forwards between this tunic and the choroid to the ciliary muscle at the outer circumference of the iris. Each artery divides into an upper and a lower branch, which form with each other and the anterior ciliary arteries a vascular circle (*circulus major*); from this circle numerous small branches pass inwards and form another circle (*circulus minor*) of anastomosis, which terminates in the veins of the iris. The *anterior ciliary arteries*, five or six in number, are derived from the muscular and lachrymal branches of the ophthalmic artery, and ramify on the tendons of the recti muscles (p. 774), where they pierce the sclerotic about the $\frac{1}{12}$th of an inch (2 *mm.*) behind the margin of the cornea. These vessels supply the ciliary processes and iris, and join the circulus major: it is from their enlargement that the red zone round the cornea is produced in inflammation of the iris.

The *veins* follow the same arrangement as the arteries, and communicate as stated (p. 778) with the canal of Schlemm.

The *nerves of the iris* come from the nasal branch of the ophthalmic nerve, and by twelve to fifteen branches from the lenticular ganglion. They pierce the sclerotic around the en-entrance of the optic nerve, and run forwards between the sclerotic and the choroid as far as the ciliary muscle. On the choroid they form a gangliated plexus which lies in connection

* The circular fibres of the iris in the bird are of the striped variety, and discernible without difficulty.

with and among the blood-vessels. In the ciliary muscle the nerves form another plexus, from which numerous non-medullated fibrils are given off to terminate in the muscular tissue of the iris. The sphincter iridis is supplied through the motor root of the lenticular ganglion which is derived from the third nerve; the dilatator iridis is supplied by the sympathetic system.

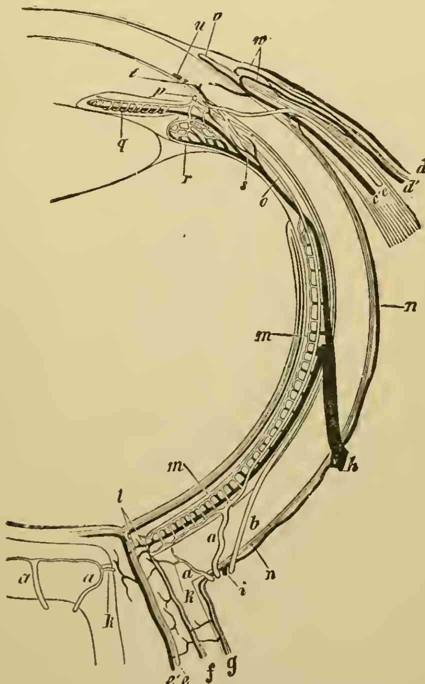


FIG. 304. — HORIZONTAL SECTION OF EYE SHOWING THE BLOOD-VESSELS.

a, a. Short posterior ciliary. *b.* Long posterior ciliary. *c. c′.* Anterior ciliary artery and vein. *d, d′.* Artery and vein of conjunctiva. *e, e′.* Central artery and vein of retina. *f.* Blood-vessels of the inner, and *g,* of the outer optic sheath. *h.* Vorticose vein. *i.* Posterior short ciliary vein confined to the sclerotic. *k.* Branch of the posterior short ciliary artery to the optic nerve. *l.* Anastomosis of the choroidal vessels with those of the optic. *m.* Choriocapillaris. *n.* Episcleral branches. *o.* Recurrent choroidal artery. *p.* Great circular artery of iris (transverse section). *q.* Blood-vessels of the iris. *r.* Ciliary process. *s.* Branch of a vorticose vein from the ciliary muscle. *t.* Branch of the anterior ciliary vein to the ciliary muscle. *u.* Circular vein. *v.* Marginal loops of vessels on the cornea. *w.* Anterior artery and vein of the conjunctiva.

Membrana Pupillaris. — Until the seventh or eighth month of fœtal life, the pupil is closed by a transparent, vascular membrane, the *membrana pupillaris,* so that the anterior and posterior chambers are divided from each other by this membrane.

Its vessels, derived from those of the iris and capsule of the lens, are arranged in loops which converge towards the centre of the membrane without joining each other. About the eighth month this membrane becomes gradually absorbed, so that at birth it is completely lost.

Retina. — To obtain a view of the *retina*, the choroid coat must be carefully removed while the eye is under water; this should be done with the forceps and scissors on a fresh eye. When the choroid is thus removed, there will be seen on its inner surface a layer of pigmented cells, which has been already referred to as really the external layer of the retina, and not in any way part of the choroid coat. The optic nerve, having entered the interior of the globe through the sclerotic and the choroid, expands into the delicate nerve layer, called the retina, which forms the third tunic of the globe. The retina is in contact, externally, with the choroid; internally, with the hyaloid membrane, which separates it from the vitreous; and it extends forwards nearly to the posterior margin of the ciliary processes, where it terminates in a thin serrated border — the *ora serrata;* from this border a thin membrane — *pars ciliaris retinæ* — destitute of nerve fibres, is continued forwards to the tips of the ciliary processes, and thence to the posterior surface of the iris.

In passing through the coats of the eye, the optic nerve becomes gradually constricted and reduced to one-half of its diameter; here it presents a round disk, called the *porus opticus*, in the centre of which may be seen the arteria centralis retinæ. At this point, too, the nerve-substance projects slightly into the interior of the globe, forming a little prominence, to which the term *colliculus nervi optici* has been applied. This prominence is remarkable, in that it is insensible to the rays of light, and is hence called the 'blind spot.'

The retina when fresh is nearly transparent, but soon it becomes of a pink milky tint. Precisely opposite the pupil, in the centre of the axis of vision, there is an oval yellow spot, *macula lutea*, in the retina, about $\frac{1}{20}$th of an inch (*1.2 mm.*) in diameter, having a depression, *fovea centralis*, in the centre, and fading off gradually at the edges.

Here vision is most perfect, so that it might be called the "spot of light." This central spot was believed by its discoverer, Sömmering, to be a perforation; but it is now ascertained to be due to the pigmentary layer of the retina showing

through it. These appearances are lost soon after death, and are replaced by a minute fold, into which the retina gathers itself, reaching from the centre of the spot to the prominence of the optic nerve.*

Structure. — Although to the naked eye the retina appears a simple, soft, semi-transparent membrane, yet when examined under the microscope it is found to be most minutely and elaborately organized. It varies in thickness from the $\frac{1}{50}$th to the $\frac{1}{100}$th of an inch (*.45* to *.14 mm.*), being thickest behind, and gradually diminishes towards the front. It consists of eight layers, through which may be traced a considerable amount of extremely delicate connective tissue (*fibres of Müller*), which constitutes a sustentacular tissue for the various strata, and is said to form for them two more or less continuous boundary layers, termed *membranæ limitantes interna* and *externa*, and which are classed by some anatomists as two additional layers. The layers of the retina are as follows, beginning from within: —

1. The layer of nerve fibres.
2. The ganglionic layer.
3. The inner molecular layer.
4. The inner nuclear layer.
5. The outer molecular layer.
6. The outer nuclear layer.
7. The layer of rods and cones.
8. The pigmentary layer.

The membranæ limitantes are situated as follows: the internal stratum lies on the inner surface of the layer of nerve-fibres; the external, between the outer nuclear layer and the layer of rods and cones.

The *layer of nerve-fibres* (Fig. 305, 1) is composed of the spreading out of the optic nerve fibres, and of connective tissue cells. The nerve-fibres, consisting only of the axis-cylinders, run forwards as a continuous layer to the ora serrata, partly arranged in bundles and partly in plexuses, and become connected with the nerve-cells of the next layer. The fibres are almost absent on the yellow spot.

2. The *ganglionic layer* (Fig. 305, 2) is a stratum of spheroidal nerve-cells; from the deeper part of each cell there is given off a single elongated process, which passes obliquely into the nerve-fibre layer, with which it becomes continuous; from the outer side of the cell two or more processes are given off, which branch dichotomously and become at first embedded and then lost in the inner molecular layer. The ganglionic cells, which in the greater part of the stratum form a single layer, are at the yellow spot arranged eight or ten deep, and in its neighborhood two or three deep.

3. The *inner molecular layer* (Fig. 305, 3) is a granular stratum of considerable thickness which exhibits, under high powers, a recticular structure, having small

* In birds the retina has throughout the yellowish color seen only at one part in the human eye.

interstices filled probably with lymph. In it are found the processes of the nerve cells of the preceding layer, which pass outwards for a considerable distance, some varicose filaments which pass inwards from the next layer; and some Müllerian fibres which pass through this layer. Other cells, like those found in the nerve-fibre and ganglionic layers, are also found in this stratum, chiefly on its surfaces.

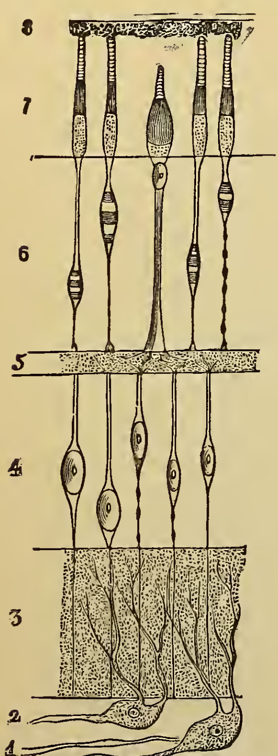


FIG. 305.—DIAGRAM OF THE VARIOUS LAYERS OF THE RETINA. (*After Schwalbe.*)

1. Layer of nerve-fibres, Membrana limitans interna. 2. Layer of nerve-cells. 3. Inner molecular layer. 4. Inner nuclear layer. 5. Outer molecular layer. 6. Outer nuclear layer. 7. Layer of rods and cones. (Membrana Jacobi.) Membrana limitans ext. 8. Layer of pigment cells.

4. The *inner nuclear layer* (Fig. 305, 4) contains three kinds of cells, and some fibres which belong to the Müllerian or connective tissue fibres of the retina. The first kind consists of oval bipolar cells placed longitudinally, and having a distinct nucleus and nucleolus; from the inner extremities of these cells there extend long varicose, thin processes which pass vertically downwards, without division, into the inner molecular layer, and are presumably connected with the processes of the ganglionic layer and thence with the nerve-fibres; from the outer extremities of the cells pass processes, thicker than the ones just described and not varicose, which pass to the next layer and there break up into numerous filamentous processes. The second kind of cells are small, granular, protoplasmic cells, which are confined to the deeper part of this layer; and the third kind, similar in their appearance, are disposed here and there in the most external stratum of the inner nuclear layer. The course which the Müllerian fibres take through this layer will be described later on.

5. The outer *molecular* or *internuclear layer* (Fig. 305, 5) resembles in most respects the inner molecular layer, but is much thinner. It contains, however, numerous flattened, branched cells, having well-marked nuclei and nucleoli, and whose fine branching processes exhibit varicosities in their course, resembling nerve-fibrils. Whether these are nerve-fibres or only the fibres of the sustentacular tissue is at present not determined; but this layer, as well as those already described, is developed in the same manner as those of the brain, so that probably these fibres are nerve-fibrils.

6. The *outer nuclear layer* (Fig. 305, 6) consists of a thick stratum of nucleated cells, having outward and inward prolongations, which may be recognized as connected respectively with the rods and cones of the next layer. The *rod-granules* are the most numerous, and each presents an oval cell, which has a well-marked transverse striation, due to the highly refracting substance being crossed by disks of a less refracting medium. There are usually two, one on each side of the middle of the cell. From this enlargement one varicose filament passes inwards and becomes connected with the outer molecular layer by a dilatation, from

which numerous filaments pass inwards; the other extremity is thicker, not varicose, and passes outwards towards the membrana limitans externa, where it becomes somewhat expanded, and then becomes continuous with a rod. The *cone-granules* are fewer, and each has an oval nucleated cell, which presents no transverse striation characteristic of the rod-granule. The cell is situated close to the membrana limitans externa, and rests upon a thick cone-fibre, much thicker than a rod-fibre, which enlarges as it approaches the outer molecular layer, upon which it rests by a pyramidal base. From this base numerous fine processes are given off into the molecular layer; the outer extremity is very short and broad, and supports the base of a cone.

7. The *layer of rods and cones, basillary layer* or *Jacob's membrane* (Fig. 305, 7), is composed of minute cylindrical elements, arranged at right angles to the surface of the retina. The *rods*, the more numerous, are tapering processes running through the whole thickness of this layer, and, externally, are embedded to a greater or less depth in the pigmented layer, so that when viewed from without they have the appearance of a mosaic pavement made up of round segments. Among the rods are intermingled numerous shorter, flask-shaped bodies called *cones*, which do not extend through more than half the thickness of this layer. Their outer extremities taper off towards the choroid; their inner or broad ends, like the rods, rest upon the membrana limitans externa, and thence are connected with the outer nuclear layer. Each rod and cone consists of two segments of equal lengths; the inner, in the case of the cones, very broad and bottle-shaped, of the rods only slightly bulged; the outer, fine and tapering off. The two segments vary in their microscopic appearance and in relations to reagents; the outer segments of both have a transverse striation, and break up in the direction of this striation; the inner segments are composed externally of longitudinal fibrillæ, internally of finely granular homogeneous substance continuous with the rod or cone fibre. The inner segments are deeply stained by carmine, iodine, etc., the outer segments not by the same reagents, but are by osmic acid. The rods are absent at the yellow spot.

8. The *pigmentary layer* (Fig. 305, 8) is usually described as forming part of the choroid coat, but it should, both developmentally and physiologically be included as one of the layers of the retina. It consists of a single layer of hexagonal nucleated cells filled with pigment-granules, which are most numerous towards the margins of the cells. The surface of the cells which looks towards the choroid is smooth and destitute of pigment-granules, and it is here that the nucleus is situated; the surface towards Jacob's membrane is filled with pigment, which is not well defined, but runs down among the rods, so that their outer part is embedded among the pigment-cells. The use of the pigment is to absorb the rays of light which pass through the retina, and thus prevent their being reflected. It serves the same purpose as the black point with which the inside of optical instruments is darkened. Albinoes, in whom this layer has little or no pigment, are, consequently, dazzled by daylight and see better in the dusk.*

The *sustentacular tissue* (*Müllerian fibres*) is a tissue which runs through the greater thickness of the retina, beginning at the so-called membrana limitans interna, and ending at the membrana limitans externa; but in neither of these two situations does it form a continuous layer, so that it cannot be classed under the layers forming the retina. These fibres are probably of the nature of a delicate connective tissue, which serves to sustain the various layers and their constituent elements. Each fibre begins by a broad conical base, on the deeper aspect of the layer of nerve-fibres (the bases of these fibres being more or less in connection with

* In many of the nocturnal carnivorous quadrupeds, the inner surface of the choroid at the bottom of the eye presents a brilliant color and metallic lustre. It is called the *tapetum*. By reflecting the rays of light a second time through the retina, it probably enables the animal to see better in the dusk. It is the cause of the well-known glare of the eyes of cats and other animals; and the great breadth of the luminous appearance arises from the dilatation of the pupil.

each other); it then passes through the layers of nerve-fibres and ganglionic cells, and consequently the inner molecular layer, gradually diminishing in thickness; on reaching the inner nuclear layer it gives off thin filamentous processes which support the structures of this stratum, presenting here a lateral bulge with a well-marked nucleus. After passing through the outer molecular layer it reaches the outer nuclear layer, and then breaks up into filaments which join with fibrils from other Müllerian fibres, thus enclosing and supporting the cells and their prolongations of this layer. These filamentous offsets reach as far as the bases of the rods and cones, forming a bed on which they rest; this is described as the membrana limitans externa.

The *structure* of the *macula lutea* and *fovea centralis* (Fig. 306). — In the *macula lutea*, the nerve-fibres do not form a continuous layer; the ganglionic layer consists of cells six to eight deep; there are no rods; the cones are longer and narrower than elsewhere: and the outer nuclear layer has only cone-fibres. In the *fovea centralis* there are no rods, and the cones are longer than in the macula and all the other layers are much thinned. At the margin of the fovea most of the layers are thicker than elsewhere.

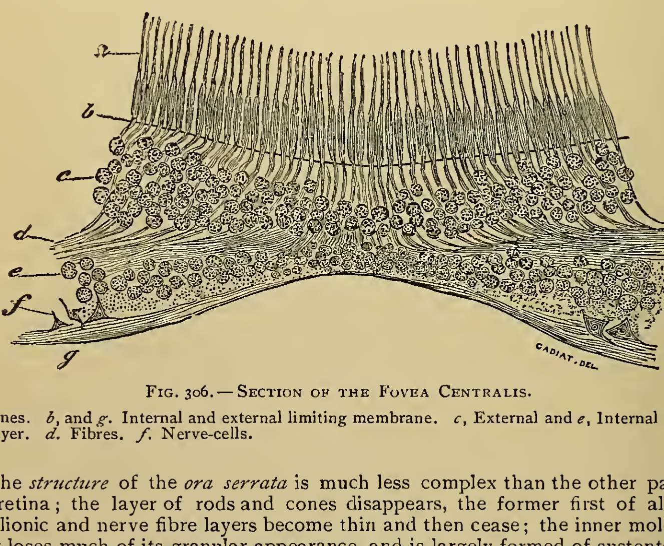


FIG. 306. — SECTION OF THE FOVEA CENTRALIS.

a. Cones. *b*, and *g*. Internal and external limiting membrane. *c*, External and *e*, Internal nuclear layer. *d*. Fibres. *f*. Nerve-cells.

The *structure* of the *ora serrata* is much less complex than the other parts of the retina; the layer of rods and cones disappears, the former first of all; the ganglionic and nerve fibre layers become thin and then cease; the inner molecular layer loses much of its granular appearance, and is largely formed of sustentacular tissue, and then abruptly ceases; the inner and outer nuclear layers become thinner, and then gradually merge into a single layer, which is continued on to the *pars ciliaris* as a single stratum of columnar epithelial cells.

The *arteria centralis retinæ*, after emerging through the porus opticus, divides into two branches — an *upper* and a *lower* — which then form a delicate network of blood-vessels throughout the nerve-fibre layer, penetrating as far as the inner nuclear layer, beyond which no capillaries can be traced. After maceration in water, the nervous substance can be removed with a camel's-hair brush, and then in an injected eye the network

formed by the vessels can be distinctly seen. The arteries of the retina do not communicate directly with the choroidal vessels.

Aqueous Humor. — The *aqueous humor* consists of a few drops of an alkaline clear watery fluid, which fills the space between the cornea and the lens.* The iris lies in it, and divides the space into two chambers of unequal size — an anterior and a posterior. The *posterior* is much the smaller of the two: indeed, the iris rests on the capsule of the lens, so that, strictly speaking, there is no interval between the opposed surfaces, except a triangular interval bounded by the attachment of the iris, the ciliary processes, and the zone of Zinn. This accounts for the frequent adhesions which take place during inflammation of the iris, between the iris and the capsule of the crystalline lens.† A delicate layer of epithelium covers the posterior surface of the cornea, but nothing like a continuous membrane can be demonstrated on the iris or the capsule of the lens. The *anterior* chamber is remarkable for the rapidity with which it absorbs and secretes; as is proved, in the one case, by the speedy removal of extravasated blood; in the other, by the rapid reappearance of the aqueous humor after the extraction of a cataract.

The Vitreous Body and the Hyaloid Membrane. — The vitreous body is a transparent, gelatinous-looking substance, which fills up nearly four-fifths of the interior of the globe (Fig 301). It can be easily separated from the retina, except at the optic disk; in front it presents a deep depression, in which the crystalline lens is embedded. It is surrounded, except in front, by a delicate transparent membrane — the *hyaloid membrane* — which forms a capsule for the vitreous body, and is sufficiently strong to keep it in shape after the stronger tunics of the eye have been removed.

When the vitreous humor has been hardened in chromic acid it is rendered somewhat opaque, and presents, especially at its outer part, a lamellar appearance. It consists of a fluid contained in the meshes of a cellular structure, which communicate freely with each other; for if any part of it be punctured, the humor gradually drains away.‡ If examined carefully, the lamellation is seen to be arranged concentrically, the layers, as they approach the centre, becoming less firm in consistence. The vitreous, moreover, on a transverse section, shows a radial striation, but whether this exists naturally, or is the result of post-mortem changes,

* The solid constituent is mainly composed of chloride of sodium.

† Some anatomists describe the anterior chamber as lined by a serous membrane called the membrane of the aqueous humor.

‡ This is composed mainly of water, with albuminate of soda and mucin.

or from chemical reagents, is not known. Running through the middle from before backwards is a small canal—*canal of Stilling*—about 1 mm. in diameter, which contains fluid, and is broader behind than in front; this in the fœtus lodges a small branch of the retinal artery, which ramifies on the back of the capsule of the lens.

The hyaloid membrane surrounds the vitreous body, except in front, and passes from the anterior border of that body to the margin of the lens, forming the *suspensory ligament of the lens*, and known as the *zone of Zinn.* This is best exposed by removing the ciliary processes. It appears as a dark, radiating disk, and the surface is marked by prominent ridges, which correspond with the intervals between the ciliary processes (Fig. 307). These intervals are in life filled with fluid, and perhaps with the vitreous. The hyaloid membrane, with the exception of the suspensory ligament, is a structureless membrane, but the ligament presents a structure consisting in part of longitudinal elastic fibres. Beneath the membrane, on its inner surface, are numerous granular nucleated cells, which exhibit amœboid movements. The ligament assists in maintaining the lens in its proper position, and is firmly connected with its capsule.

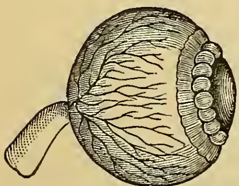


FIG. 307.—ARTERIES OF THE RETINA.

Canal of Petit (inflated). Zone of Zinn (exaggerated).

Canal of Petit.—If the transparent membrane between the zone of Zinn and the margin of the lens be carefully punctured, and the point of a small blowpipe gently introduced, and air or fluid injected, we may succeed in inflating a canal which encircles the lens: this is the *canal of Petit* (Fig. 307). It is triangular in section, and bounded in front by the suspensory ligament of the lens; behind, by the vitreous body; and its base, by the capsule of the lens. When inflated, it becomes sacculated, as in Fig. 307, owing to the foldings on the front surface of the lens.

Crystalline Lens.—The *crystalline lens* (Fig. 301) is a perfectly translucent solid body, situated immediately behind the pupil, partly embedded in the vitreous body, and completely surrounded by a capsule equally translucent. It is convex on both sides, but more so behind. In early life it is nearly spherical and soft, but it becomes more flattened, firmer, and amber-colored with advancing age. In the adult its transverse diameter is about one-third of an inch (*9 mm.*); its antero-posterior, one-seventh of an inch (*3.7 mm.*)

The *capsule of the lens* is a transparent, elastic, and brittle membrane. It resembles in structure the elastic layer of the cornea, and is much thicker in front than behind; in front, it is in contact with the posterior surface of the iris; behind, it rests in the depression of the vitreous body. The capsule in front is separated from the lens by a layer of polygonal nucleated cells, and, after death, a layer of fluid is interposed between the capsule and the lens, constituting the *liquor Morgagni;* behind, no such layer of epithelium exists. No vascular connection whatever exists between the lens and its capsule.* The lens protrudes directly the capsule is sufficiently opened.

Structure of the Lens. — The minute structures of the lens can only be made out after being hardened. It is soft, almost gelatinous in consistence outside, but each successive concentric layer becomes more dense, so that the central part is hard, and constitutes the *nucleus.* It is seen to be divided into three equal parts, by three lines, which radiate from the centre to within one-third of the circumference. Each of these portions is composed of numerous concentric layers, arranged one within the other, like the coats of an onion. If any single layer be examined with the microscope, it is seen to be composed of fibres, running in a curved direction, and connected together by finely serrated edges. On the transverse section the lens-fibres are found to be hexagonal prisms, with very little connecting substance. Between the front of the lens and its capsule is a layer of flattened cells with well-marked eccentric nuclei. The beautiful dove-tailing of the fibres of the lens was first pointed out by Sir David Brewster; and to see it in perfection, one ought to examine the lens of the codfish.

The function of the lens is to bring the rays of light to a focus upon the retina.†

* The vessel of the capsule of the lens is derived from the arteria centralis retinæ, and in mammalia can only be injected in the fœtal state. In the reptilia, however, the posterior layer of the capsule is permanently vascular. This small artery passes forwards through the canal of Stilling to the posterior part of the capsule of the lens, on which it radiates into numerous small branches, communicating with branches in the iris and pupilary membrane.

† The lens contains about 60 per cent. of water, and 30 per cent. of albuminoids.

DISSECTION OF THE ORGAN OF HEARING.

The parts constituting the organ of hearing should be examined in the following order: (1) the outer cartilage or pinna; (2) the meatus auditorius externus; which leads to (3) the tympanum or middle ear; and (4) the labyrinth or internal ear, comprising the vestibule, cochlea, and semicircular canals, which contain the distribution of the auditory nerve.

Pinna. — The *pinna* or *auricle* consists of yellow fibro-cartilage covered with integument, and is irregularly concave to receive the undulations of sound. It is unevenly oval, and presents on its external aspect numerous eminences and hollows, which have received the following names: — The circumferential folded border is called the *helix;* the ridge within it, the *antihelix;* between these is a curved groove, called the *fossa of the helix.* The antihelix bifurcates towards the front and encloses the *fossa of the antihelix* (*fossa scaphoidea*). The conical eminence in front of the meatus is termed the *tragus,* on which some hairs are usually found. Behind the tragus, and separated from it by a deep notch (*incisura intertragica*), is the *antitragus.* The *lobula* is the soft pendulous part placed below the concha, and consists of fat and fibrous tissue. The deep hollow, which collects the vibrations of sound, and conveys them into the external meatus, is termed the *concha.*

Structure. — The pinna is composed of yellow fibro-cartilage, with some fat and connective tissue, covered with integument, and attached to neighboring parts, partly by fibrous tissue and partly by muscles.

The *skin* is very thin, intimately adherent to the subjacent cartilage, and provided with numerous sebaceous glands, found chiefly in the scaphoid fossa and the concha.

The *cartilage* is a single, uneven plate of fibro-cartilage, which presents all the irregularities of the external ear. The cartilage is incomplete, for there is a deficiency behind the tragus at the bottom of the concha, which is filled up with fibrous tissue. It has a tubular prolongation inwards, which forms the external

part of the meatus auditorius externus. The cartilage presents several fissures (*fissures of Santorini*) at the anterior part of the tubular prolongation, which are completed by fibrous tissue. In the front part of the pinna, where the helix makes its first bend, is a conical projection of cartilage, termed the *process of the helix*. The lobule, attached to the lower part of the pinna, is a rounded projection formed of fat and connective tissue; it is this which enlarges with age and obesity of the subject.

Ligaments. — The ligaments are: the *anterior ligament*, broad and strong, which passes from the process of the helix to the root of the zygoma; the *posterior ligament*, which extends from the cranial surface of the concha to the mastoid process of the temporal bone. There are also *intrinsic ligaments* which bridge over and fill up the deficiencies in the pinna.

Muscles of the Pinna. — The muscles which move the cartilage of the ear as a whole, have been described (page 21). Other small muscles extend from one part of the cartilage to another; but they are so indistinct that, unless the subject be very muscular, it is difficult to make them out. The following six — four on the front of the auricle and two behind it — are usually described: —

(*a*) The *musculus major helicis* runs vertically along the front margin of the helix: it arises below from the process of the helix, and is inserted into the curve of the helix as it passes backwards.

(*b*) The *musculus minor helicis*, an oblique muscle, lies over that part of the helix which is connected with the concha.

(*c*) The *musculus tragicus* lies vertically over the outer surface of the tragus.

(*d*) The *musculus antitragicus* passes transversely from the antitragus to the lower part of the tail-like process of the helix behind the lobule.

(*e*) The *transversus auriculæ* is on the cranial aspect of the pinna; it passes nearly transversely from the back of the concha to the prominence corresponding to the fossa of the helix.

(*f*) The *obliquus auris* extends vertically from the cranial aspect of the concha to the convexity below it.

The *arteries* of the pinna are derived from the posterior auricular, and from the auricular branches of the temporal and occipital. The *veins* empty themselves into the temporal vein. The *nerves* are furnished by the great auricular branch of the superficial cervical plexus, the auriculo-temporal branch of the inferior maxillary, the posterior auricular branch of the facial, and the auricular branch of the pneumogastric.

Meatus Auditorius Externus. — This oval passage leads down to the membrana tympani, and conveys the vibrations of sound to the tympanum. It is about an inch and a quarter (*3.1 cm.*) in length; its external opening is longest in its vertical direction: its termination is broadest in its transverse. The canal inclines at first upwards and forwards, and then curves a

little downwards.* Its floor, owing to the oblique direction of the membrani tympani, is a little longer than the roof. It is not of equal calibre throughout, the narrowest part being about the middle; hence the difficulty of extracting foreign bodies which have passed to the bottom of the canal. It is formed, partly by a tubular continuation of the cartilage of the pinna, partly by an osseous canal in the temporal bone.

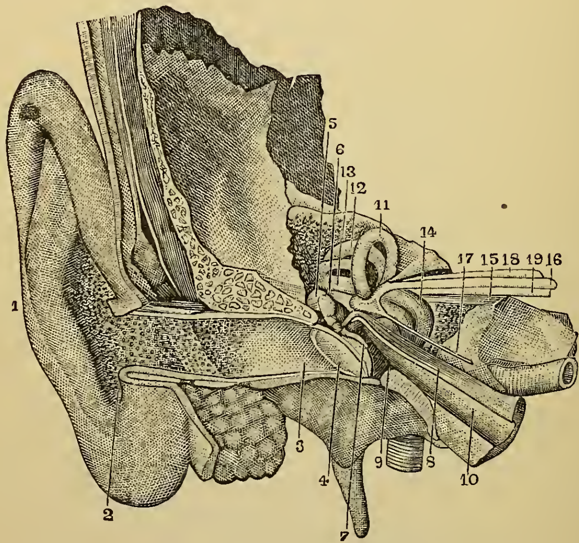


FIG. 308.— VERTICAL SECTION OF EAR.

1. Pinna or Auricle. 2. Concha with orifices of sebaceous and ceruminous glands. 3. Osseous portion of external auditory canal. 4. External surface of the membrani tympani. 5. Anterior part of the incus. 6. Head of the malleus. 7. Handle of the malleus lodged between the internal and middle layers of the membrani tympani. 8. Tensor tympani m. with its tendon at a right-angle to be attached at the inner margin of the base of the handle of the malleus. 9. Cavity of the tympanum. 10. Expanded portion of the Eustachian tube. 11. Superior semicircular canal. 12. Posterior semicircular canal. 13. External semicircular canal. 14. Cochlea. 15. The internal auditory canal where the wall has been taken away to show the nerves which it transmits. 16. Facial nerve. 17. The great superficial petrosal nerve passing from the geniculate ganglion of the facial to reach its destination. 18. Vestibular branch of the auditory nerve. 19. Cochlear branch of the auditory nerve.

The *cartilaginous portion* is about half an inch (*13 mm.*) long, and is firmly connected to the osseous portion. The cartilage is incomplete at the upper and back part, and the interval is filled in with fibrous tissue.

* To obtain a correct knowledge of the length and dimensions of the meatus, sections should be made through it in different directions, or a cast be taken of it in plaster of Paris.

The *osseous portion*, about three-quarters of an inch (*19 mm.*) in length, is narrower than the cartilaginous portion, and is curved forwards and inwards. Its outer extremity is rough for the attachment of the cartilage; its inner presents a narrow groove, except at the upper part, for the insertion of the membrana tympani. The lower and anterior wall of the osseous portion is formed by a semicircular plate of bone, the *tympanic plate*, the outer border of which is thickened and is termed the *external auditory process*.

The *skin* and the cuticle are continued down the passage, and becoming gradually thinner, form a cul-de-sac over the membrana tympani. The outer portion is furnished with hairs and ceruminous glands, which secrete the cerumen or wax, and are only found over the cartilaginous portion of the canal.

Its *arteries* are derived from the posterior auricular, the internal maxillary and the temporal, all branches of the external carotid artery. Its *nerves* come from the auriculo-temporal branch of the inferior maxillary or mandibular nerve.

Tympanum. — The *tympanum*, or middle ear, is an irregular cavity in the petrous part of the temporal bone: having on its outer side the membrana tympani; on its inner side the labyrinth; behind, the mastoid cells; in front, the carotid canal; below, the wall of the jugular fossa. It is rather less than half an inch (*13 mm.*) in its long diameter; from $\frac{1}{6}$ to $\frac{1}{12}$ of an inch (*4 to 2 mm.*) between its outer and inner boundaries; and a quarter of an inch (*6 mm.*) in its vertical direction. It is lined with mucous membrane and filled with air, which is freely admitted through the Eustachian tube; so that atmospheric pressure is equal on both sides of the membrane. A chain of small bones, the *ossicles*, retained in their position by ligaments and acted upon by muscles, passes across it. The use of these bones is to communicate the vibrations of the membrana tympani to the labyrinth. For this purpose one end of the chain is attached to the membrane, the other to the fenestra ovalis. The tympanum is bounded by a floor, a roof, an outer, an inner, an anterior, and a posterior wall.

Its *roof* is formed by a thin plate of bone corresponding with the anterior surface of the pars petrosa, which separates the tympanum from the cranial cavity.

The *floor*, which is narrow, is formed by a thin plate, corresponding to the jugular fossa beneath: it is perforated in front by a small aperture for Jacobson's nerve.

Its *outer wall* is formed mainly by the membrana tympani, and by a ring of bone which affords attachment to it; the latter is pierced by the fissura Glaseri (which gives passage to the processus gracilis of the malleus, the laxator tympani, and the tympanic branch of the internal maxillary artery), by the foramen chordæ posterius, through which the chorda tympani enters the tympanum, and by the foramen chordæ anterius, which is the commencement of the canal of Huguier, for the exit of the chorda tympani nerve.

The *inner wall* is vertical and uneven, and presents the following objects, beginning from above: 1. A horizontal *ridge*, indicating the line of the aquæductus Fallopii; 2. The *fenestra ovalis*, a reniform opening, nearly horizontal, which leads into the vestibule, but is closed in the recent state by a membrane, to which is attached the base of the stapes; 3. Below and in front of the fenestra ovalis is a convex bony prominence, the *promontory;* it is occasioned by the first turn of the cochlea, and is marked by vertical grooves, in which lie the branches of the tympanic plexus of nerves; 4. Below and behind this is the *fenestra rotunda*, which lies at the bottom of a conical depression and is overhung by a projection of bone, so that it cannot be seen, except when viewed obliquely; it leads to the scala tympani of the cochlea, but is closed in the recent state by membrane; 5. Immediately behind the fenestra ovalis is a small conical eminence, named the *pyramid*, in the summit of which is a small aperture, from which the tendon of the stapedius emerges; within the pyramid at its base is a small aperture which leads to the aquæductus Fallopii, and transmits a special filament from the facial nerve to the stapedius.

FIG. 309.—TENSOR TYMPANI MUSCLE. (*m*) The Eustachian tube (left) opened and showing the processus cochleariformis.

The *posterior wall* presents three or four openings, one of them large, which lead to the mastoid cells, and convey air into them from the tympanum. The mucous membrane of the tympanum is continued into the mastoid cells through these openings.

The *anterior wall* is pierced by an aperture for the trans-

mission of a small artery from the internal carotid. Into this wall open the *Eustachian tube*, and (in the dry bone) the canal for the *tensor tympani*, which are separated from each other by a bony septum, the *processus cochleariformis*. The *Eustachian tube* is partly osseous, partly cartilaginous; the *cartilaginous portion* has been described, p. 250; the *osseous portion*, about half an inch (*13 mm.*) in length, opens into the lowest part of the anterior wall, and is lined with mucous membrane continuous behind with that of the tympanum and in front with that of the pharynx. The *canal for the tensor tympani* terminates in the anterior wall above the Eustachian tube as a conical projection, in the apex of which is a small aperture for the tensor muscle; this projection is frequently called the *anterior pyramid*.

Lastly, a nerve called the chorda tympani (a branch of the facial) runs in an arched direction from the back to the front of the tympanum, and is covered with mucous membrane.

Membrana Tympani. — The *membrana tympani* is a thin semi-transparent oval disk, which completely closes the bottom of the meatus auditorius externus. Its transverse diameter slightly exceeds its vertical, and its circumference is set in a bony groove, so that it is stretched, somewhat like the parchment of a drum, on the outer wall of the tympanum.* Its plane is not vertical, but slants from above downwards, forming, with the floor of the meatus, an angle of 40 to 55°. It is slightly conical, the apex being directed inwards towards the tympanum, and between its layers is inserted the handle of the malleus which runs downwards and forwards to a little below the centre.

Structure. — It is composed of three layers; an outer, formed by an extremely thin layer of true skin; an inner, by the mucous membrane of the tympanum; and a middle fibrous layer; most of the fibres radiate from the attachment of the tip of the handle of the malleus in a bowed direction, so that the membrane is not a strict cone; other fibres are annular, forming a circumferential ring close to the osseous ring; these stretch over a notch in the upper part of the ring (*notch of Rivini*) so that the membrane is here flaccid and takes the name of the *membrana flaccida*.

The *arteries* to the membrane are supplied from the tympanic

* The transverse diameter of the membrane is 0.37 inch (9 mm.); its vertical diameter 0.33 inch (8 mm.).

branch of the internal maxillary, the stylo-mastoid branch of the posterior auricular, the Vidian, and the internal carotid.

Ossicula Auditus. — The three small bones in the tympanum are named after their fancied resemblance to certain implements, the *malleus*, *incus*, and *stapes*. They are articulated to each other by perfect joints, and are so placed that the chain somewhat resembles the letter Z. Their use is to transmit the vibrations of the membrana tympani to the membrane of the fenestra ovalis, and, through it, to the fluid contained within the vestibule. But they have another use, which would be incom-

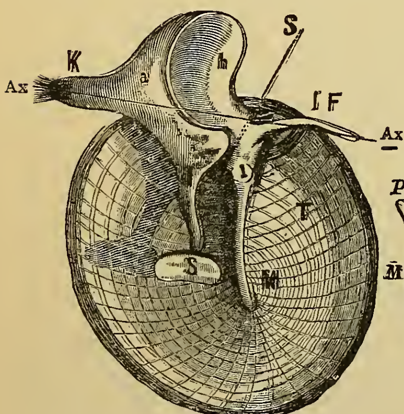


FIG. 310. — TYMPANIC MEMBRANE AND AUDITORY OSSICLES (LEFT) SEEN FROM WITHIN, (*i.e.*) FROM THE TYMPANIC CAVITY.

M. Manubrium or handle of the malleus. T. Insertion of the tensor tympani. h. Head. lF. Long process of the malleus. a. Incus with the short (k) and the long (l) process. S. Plate of the stapes. Ax. Ax. is the common axis of rotation of the auditory ossicles. S. Pinion wheel arrangement between the malleus and incus.

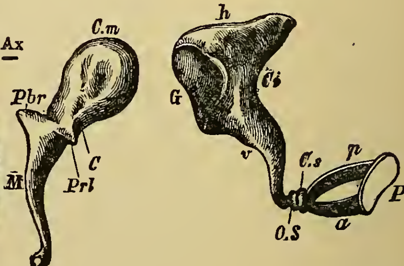


FIG. 311. — AUDITORY OSSICLES (RIGHT).

Cm. Head of the malleus. C. Neck. Pbr. Short process. Pbl. Long process. M. Manubrium or handle. Ci. Body of the incus. G. Articular surface. h. Short and v long processes. O, S. So-called lenticular ossicle. Cs. Head of the stapes. a. Anterior. p. Posterior limb or crus. P. Plate of the stapes.

patible with a single bone — namely, to permit the tightening and relaxation of the membrane, and thus adapt it either to resist the impulse of a very loud sound, or to favor a more gentle one.

The *malleus* (Fig. 311) or hammer bone, consists of an upper part or *head* (*c.m.*), which is suspended from the roof of the tympanum by the suspensory ligament, and articulates posteriorly with the incus. Below the head is a narrow constriction, the *neck* (*c*), which is continued on into a long, somewhat curved, tapering process, the *manubrium* or *handle* (*m*): it is nearly

vertical, and is attached along its whole length to the upper half of the membrana tympani, passing between its inner and middle layers. The *processus gracilis* (*Prl*) projects at a right angle below the neck, runs into the Glaserian fissure, and receives the insertion of the laxator tympani. The *processus brevis* (*Pbr*) is a stunted projection, situated at the junction of the processus gracilis and manubrium, and touches the membrana tympani; it receives the insertion of the tensor tympani.

The *incus*, or anvil bone (Fig. 311), is shaped like a tooth, with two unequal, widely separated fangs. Its broad part or *body* (*ci*) presents a concavo-convex articulation in front for the head of the malleus; its *long process* (*v*) runs nearly parallel with the handle of the malleus, and articulates with the stapes through the intervention of a small bone, the *os orbiculare*, which forms part of the long process; its *short process* (*h*) is directed horizontally backwards, and its point is fixed in a small hollow at the commencement of the mastoid cells.

The *stapes*, or stirrup bone (Fig. 311), lies horizontally. Its *head* (*cs*) articulates with the long process of the incus. Below the head is a constriction, the *neck*, which receives at its posterior part the insertion of the stapedius. Two *diverging crura* (*a. p.*) pass from the head to an oval plate of bone, the *base*, which is attached to the membrane covering the fenestra ovalis.

The tympanic bones are maintained in their positions by various ligaments. The *anterior ligament of the malleus* passes from the head of this bone to the anterior wall of the tympanum; the *suspensory ligament* descends from the root of the tympanum outwards to the head of the malleus, and the *posterior ligament of the incus* passes from the short process to the posterior wall near the mastoid cells. The ossicles are connected by an imperfect *capsular ligament*, which passes from the long process of the incus to the head of the stapes; and by another which passes from the head of the malleus to the incus. The base of the stapes is attached to the margin of the fenestra ovalis by an *annular ligament*. The surfaces of the bones forming these two little joints are covered with cartilage. The joints have also synovial membranes.

Muscles of the Tympanum. — The muscles, by moving the tympanic bones, tighten or relax the membrana tympani.

The *tensor tympani* (Fig. 309, p. 796) runs in a canal above and parallel to the Eustachian tube, from the cartilaginous part of which it *arises*, as well as from the apex of the petrous portion

of the temporal bone. It passes backwards, and terminates in a round tendon, which enters the front wall of the tympanum through a special bony canal, and, making a sharp bend outwards, is *inserted* into the root of the handle of the malleus. Its nerve comes from the otic ganglion. Its action is to draw inwards the head of the malleus, and thus render the membrane tense.

The *laxator tympani arises* from the spinous process of the sphenoid, and the cartilaginous portion of the Eustachian tube, and is *inserted* into the neck of the malleus close to the root of the processus gracilis. It is supplied by a branch of the facial nerve.* Its action is to relax the membrana tympani.

The *stapedius arises* from the hollow of the pyramid, and its tendon, emerging through the aperture in the apex, runs forwards to be *inserte*d into the neck of the stapes.† Its nerve is derived from the facial. By its action it increases the tension upon the fluid in the vestibule.

The *mucous membrane* of the tympanum is continuous with that of the pharynx. It covers the ossicles, muscles, and nerves, and is prolonged into the mastoid cells. The membrane is pale and thin, and lined with columnar ciliated epithelium, except on the promontory, the membrana tympani, and the ossicles, where there is only a single layer of flattened cells.

FIG. 312.—RIGHT-STAPEDIUS MUSCLE EMERGING FROM THE PYRAMID.

A branch (*chorda tympani*) of the facial nerve enters the tympanum through a foramen, *foramen chordæ posterius*, at the base of the pyramid; it then crosses the tympanum beneath the handle of the malleus and the long process of the incus, leaves the tympanum through a foramen, *foramen chordæ anterius*, and then traverses a canal (*canal of Huguier*), which runs close to the Glaserian fissure. It eventually joins the submaxillary ganglion (p. 153).

The *arteries* supplying the *tympanum* are: (1) the *tympanic* branch of the internal maxillary, which enters through the fissura Glaseri; (2) the *stylo-mastoid* branch of the posterior auricular; (3) small branches from the ascending pharyngeal, which enter with the Eustachian tube; (4) branches from the internal

* This is usually regarded as a muscle, and is described here as such; no muscular fibres, however, can be traced in it, so that it is probably only ligamentous in structure — a fact borne out in the lower animals.

† There is a little sheath, lined with synovial membrane, to facilitate the play of the tendon in the pyramid.

carotid artery; and (5) the petrosal branch of the arteria meningea media (*mididural*).

The *veins* open into the middle meningeal and the pharyngeal veins.

The mucous membrane is supplied with branches from the tympanic plexus, which is formed by filaments from the tympanic branch of the glosso-pharyngeal nerve, from the carotid sympathetic plexus, and from the large and small superficial petrosal nerves.

Internal Ear. — This, in consequence of its complexity, is called the *labyrinth.* It consists of cavities excavated in the most compact part of the temporal bone, and it is divided into three parts: a middle one, called the *vestibule*, being the common cavity in which all communicate; an anterior, named, from its resemblance to a snail's shell, the *cochlea;* and a posterior, consisting of *three semicircular canals;* it communicates externally with the tympanum by means of the fenestra ovalis and rotunda, and internally with the meatus auditorius internus. These cavities are filled with a clear fluid, called the *endolymph*, and contain a membranous expansion, the *membranous labyrinth*, upon which the filaments of the auditory nerve are expanded.

Vestibule. — The *vestibule*, or central chamber, is an irregular oblong cavity, about one-fifth of an inch (*5 mm.*) in its widest part, which is at its antero-posterior and at its vertical diameters. On its *outer wall* is the fenestra ovalis, which is closed in the recent state by the base of the stapes; on its *inner wall*, at the front part, is a shallow round depression, the *fovea hemispherica*, which is perforated at its lower by numerous foramina, *macula cribrosa*, for the transmission of the filaments of the auditory nerve. Posteriorly, this pit is bounded by a ridge, the *crista vestibuli*, and in some subjects there is behind this eminence the opening of a small canal, called the *aquæductus vestibuli.* It leads to the posterior surface of the pars petrosa, and transmits a small vein. In the *roof* is a transverse oval depression, the *fovea hemielliptica*, which lodges the utricle; *posteriorly*, the five openings of the semicircular canals open into it; and, *in front*, is a large opening through which it communicates with the scala vestibuli of the cochlea.

Semicicular Canals. — The *semicircular canals*, three bony canals, are situated above and rather behind the vestibule. Each canal forms about two-thirds of a circle, is compressed lat-

erally, and is about $\frac{1}{20}$th of an inch (*1.2 mm.*) in diameter. The canals are not of equal diameter throughout; each presents at one end a dilatation termed the *ampulla*, about $\frac{1}{10}$th of an inch (*2.4 mm.*) in diameter. This dilatation corresponds to a similar dilatation of the membranous sac, upon which the auditory nerve expands. The canals open at each extremity into the vestibule by five openings, since one of the apertures is common to the extremities of two canals. Each canal differs in its direction; they are named accordingly superior, posterior, and external.

The *superior semicircular canal* (Fig. 313, 1) is the most anterior of the three; its direction is vertical, and runs across the petrous bone. It rises up higher than any other portion of the labyrinth, and its ampulla is at the outer and anterior extremity, and opens into the upper part of the vestibule; its non-ampullated extremity opens by a common orifice with the posterior semicircular canal into the back part of the vestibule.

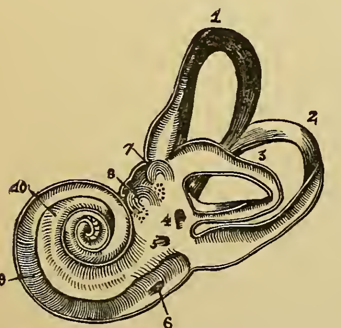


Fig. 313. — Osseous Labyrinth of the Right Side (*Opened*) (*Sömmering*). (Two and a half times its natural size.)

1. The superior semicircular canal. 2. The posterior semicircular canal. 3. The external semicircular canal. 4. Common opening of the superior and posterior semicircular canals. 5. Aquæductus vestibuli. 6. Aquæductus cochleæ. 7. Fovea hemi-elliptica. 8. Fovea hemispherica. 9. Scala tympani. 10. Scala vestibuli.

The *posterior semicircular canal* (Fig. 313, 2) is also vertical, and runs parallel to the posterior surface of the petrous bone, consequently at right angles to the preceding. It is the longest of the three canals, and its ampullated extremity is at the lower end, opening into the lower and back part of the vestibule. Its upper non-dilated end joins with that of the superior semicircular canal.

The *external semicircular canal* (Fig. 313, 3) is the shortest of the three, is horizontal in position, with the convexity of the arch diverted backwards; it opens by its extremities directly into the back of the vestibule; the ampulla is at the outer end and opens into the vestibule just above the fenestra ovalis.

Cochlea. — The *cochlea* is the most anterior part of the osseous labyrinth; it very closely resembles a common snail's shell, and is placed nearly horizontally, so that its first coil is

directed forwards and outwards, and corresponds with the promontory; while its base corresponds to the bottom of the meatus auditorius internus, and is perforated by apertures for the transmission of the cochlear branches of the auditory nerve. The diameter of its base, and also of its height, is about the same, namely, a quarter of an inch (*6 mm.*). It consists of a gradually tapering spiral tube, which winds round a central pillar, called the *modiolus* or *columella*. The spiral canal is divided into two parallel tubes, *scalæ*, by a delicate lamina, partly bony, partly membranous, which is called the *lamina spiralis*. In the dry condition this partition is only partial; but in the recent state it is completed by a membrane.

The *spiral canal* (Fig. 313, 9, 10) is about an inch and a half (*3.8 cm.*) long, and about the $\frac{1}{10}$th of an inch (*2.4 mm.*) in diameter, lessening as it approaches the summit. After making two turns and a half it terminates at the apex of the cochlea in a rounded dome — the *cupola*. The coil at the base is the widest, the second being a very small one. The canal has in it three openings; thus it communicates with the vestibule by an oval opening; with the tympanum by the fenestra rotunda, but which in the recent state is closed by the *membrana secundaria*; and, lastly, there is the aperture of the *aquæductus cochleæ*, which transmits a small vein from the cochlea to the internal jugular vein.

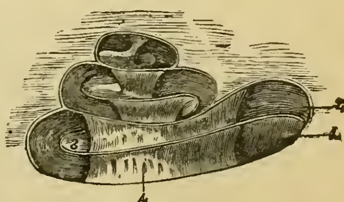


Fig. 314.—The Osseous Cochlea. (Magnified Five Times.)

1. Scala tympani. 2. Scala vestibuli. 3. Lamina spiralis ossea. 4. Modiolus, or central pillar.

The *modiolus* or *columella* (Fig. 314, 4) is the central pillar of the cochlea around which the spiral canal coils, and it passes from the base to the apex. It is of considerable thickness at its base, but gradually tapers towards the apex, where at the last half coil it terminates in a half-funnel-shaped curved lamella, called the *infundibulum*. Here the partition disappears, and is called the *helicotrema*, so that the scalæ vestibuli and cochleæ communicate with each other in this situation. The interior of the modiolus is composed of cancellous bone, and is traversed by numerous canals, which transmit small vessels and nerves to the lamina spiralis. One of these canals, larger than the others, runs up the centre of the modiolus nearly to the apex, and transmits a small artery, the *arteria centralis modioli*.

On making a vertical section through the cochlea, we observe that the spiral canal is divided into three tubes, termed *scalæ;* the lower and largest is the *scala tympani* (Fig. 315, 1); the upper is the *scala vestibuli* (Fig. 315, 2), which is subdivided by an oblique membrane to form an outer or third tube — the *scala media* or *canalis cochleæ* (Fig. 315, 3).

The *lamina spiralis* (Fig. 314, 3) is the projecting partition which divides the spiral canal into two tubes or scalæ: it is composed on the inner half of bone — *lamina spiralis ossea* — and on the outer half of membrane — *membrana basilaris* (Fig.

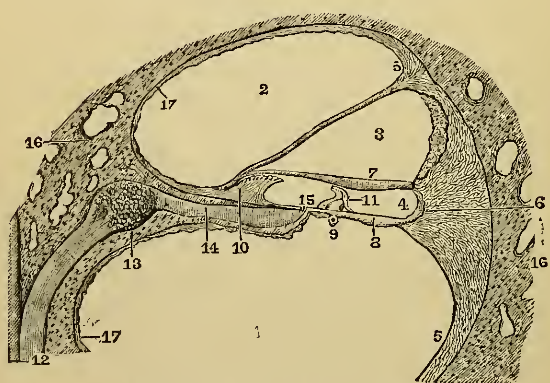


FIG. 315. — SECTION OF THE COCHLEA.

Scala tympani. 2. Scala vestibuli. 3. Scala media. 4. Canal of Corti. 5. Ligamentum Spiralis. 6. External spiral groove. 7. Membrane of corti. 8. Membrana basilaris. 9. Spiral vessel subjacent to the smooth zone of this membrane. 10. Sulcus spiralis. 11. Rods of Corti. 12. A branch of the cochlear nerve. 13. Spiral ganglion. 14. The same nerve which after having traversed the spiral ganglion, makes its way between the two laminæ of the osseous lamina spiralis. 15. One of the foramina by which this branch penetrates the canal of Corti to terminate in the organ which it comprises. 16. Bone forming the margin of the lamina. 17. Periosteum of inner wall of the cochlea.

315, 8). The lamina spiralis ossea ends at the cupola in a hook-like process — the *hamulus.* Winding round the modiolus, close to the attachment of the lamina spiralis ossea, is a small canal — the *canalis spiralis modioli* — which is filled by the gangliform swelling of the cochlear nerve, called the *ganglion spirale,* 13. The osseous lamina spiralis is seen, on a vertical section, to be composed of two plates, between which the structure is spongy; and presents a number of small canals for the passage of the small filaments of the cochlear division of the auditory nerve, in their course to the membranous part of the lamina.

On examining the membranous continuation of the lamina spiralis, it is seen, not far from its attachment to the osseous zone, to be thickened into an elongated crest — the *limbus laminæ spiralis* (Fig. 315, 7) — which overhangs a groove, called the *sulcus spiralis* (Fig. 315, 10); the upper horn of the groove is called the *labium vestibulare;* the lower, the *labium tympanicum.* From the labium tympanicum, the *basilar membrane* is continued outwards to be attached to the outer wall of the canal, and thus completes the septum. At the point of attachment of the basilar membrane with the outer wall of the cochlea may be seen a triangular projection, which, formerly described as a muscle (*cochlearis muscle*), is now recognized to be a collection of connective tissue cells, and called the *ligamentum spirale* (Fig. 315, 5). The structure of the limbus consists of firm connective tissue, on the under part of which are found numerous cells. Close to the junction of the limbus with the basilar membrane are a series of regularly arranged apertures, looking upwards to the sulcus spiralis; these are ovoid apertures for the exit of branches of the cochlear nerve.

The *basilar membrane* forms, at the base of the cochlea, but a small breadth of the septum, the broadest part being composed of bone; but it gradually increases in breadth towards the cupola, where it constitutes nearly the entire septum. It consists of a firm, fibrillated tissue, which is probably formed, at any rate on its upper surface, of a structure closely resembling the organ of Corti.

It has been stated that in the bony cochlea there is a partial septum dividing the spiral tube into two incomplete scalæ. In the recent condition the basilar membrane completes the septum dividing the upper tube into an upper canal — the scala vestibuli, and a lower, the scala tympani. The upper scala is subdivided by an oblique membrane, *membrane of Reissner*, into two canals — an inner, the *scala vestibuli*, and an outer, the *canalis cochleæ*, the *scala media* or the *ductus cochlearis* (Fig. 315, 3). The canalis cochleæ terminates at the helicotrema in a cul-de-sac; inferiorly, it is connected with the saccule by a long narrow duct called the *canalis reuniens.*

The *membrane of Reissner* is the oblique membrane which separates the scala vestibuli and the canalis cochleæ. It is a delicate, almost structureless layer, composed of connective tissue, continuous with the periosteum lining the upper surface

of the lamina spiralis. It is smooth on its vestibular surface, and is lined with flattened connective-tissue cells; on its cochlear surface it is covered with squamous epithelium.

The *inner wall* of the canalis cochleæ is formed by the membrane of Reissner covered with pavement epithelium. The *outer wall*, the periosteum, is thickened by a quantity of retiform connective-tissue lined with columnar epithelial cells. An increase of this tissue is seen a little above the ligamentum spirale as a conical eminence, in which runs a small vessel, the *vas spirale;* midway between the vas and the attachment of Reissner's membrane is another thickening, consisting also of numerous blood-vessels, *stria vascularis*, which form anastomosing loops. The lower wall is formed by the limbus spiralis and the basilar membrane; upon the latter is placed the complex structure, called the organ of Corti.

The *organ of Corti*, placed upon the upper surface of the membrana basilaris, presents a slight triangular elevation outside the limbus, and winds spirally throughout the cochlea from its base to its summit. The central part of the organ (Fig. 315, 11) consists of two sets, an inner and an outer, of slanting rods — *rods of Corti* — which rest against each other at their upper extremities, thus forming a triangular tunnel, called the *tunnel of Corti*, filled in the recent state with endolymph. The inner and the outer rods are similar in structure, but differ in shape — the inner are shorter, less oblique, and have the shape of the human ulna, the outer resemble the swan's head, the head being received into the concavity of the inner rod, the part resembling the bill looking horizontally outwards. Both have a broad nucleated base, and present a fibrillar appearance. The inner rods are more numerous than the outer.*

On the inner side of the inner rods is a single row of broad epithelial cells tipped with stiff ciliated processes, called the *inner hair cells;* and on the outer side of the outer rods, resting on cells which are placed on the basilar membrane, are four to six rows of similar cells, termed the *outer hair cells* (316, o c). The bases of the outer hair cells present on one side a rounded bulge, while from the other are long processes which pass downwards to be attached to the membrana basilaris. The outer rods are placed upon numerous fusiform nucleated cells, *cells of Deiters*, whose bases rest upon the basilar membrane, and

* According to Waldeyer, in the proportion of 6,000 of the inner to 4,500 of the outer rods.

whose summits taper off into fine long cubicular processes, *phalageal*, which pass between the outer hair cells to be connected to the phalanges of the reticular lamina.

The *lamina reticularis* is the net-like membrane surmounting the summits of the outer hair cells. It is an open network, of a fiddle-shape pattern, consisting of four rows of fiddle-shaped cells termed *phalanges*, through which the ciliated processes of

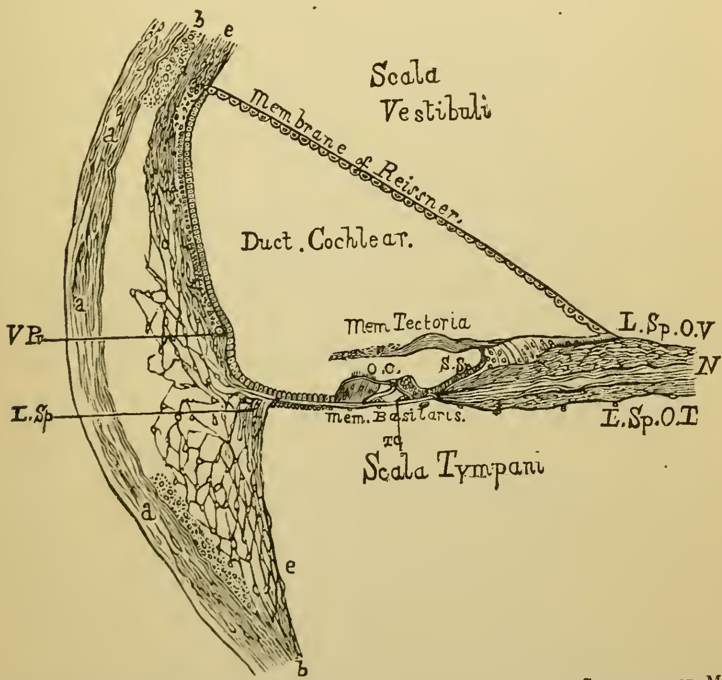


FIG. 316.—VERTICAL SECTION OF THE FIRST TURN OF THE COCHLEA, SHOWING THE MEMBRANOUS COCHLEA AND THE POSITION OF THE ORGAN OF CORTI. (*After Waldeyer and Quin.*)

the hair cells project. To these phalanges, as before stated, are attached the phalangeal processes of the cells of Deiters.

The *tectorial membrane* (Fig. 316, MEM. TECTORIA) is the only remaining membrane to be described, and lies above and parallel to the basilar membrane, but does not extend more than half-way over it. It is connected on its inner side with the limbus spiralis, and is then continued outwards, overlying and resting upon the rods of Corti; at its origin it is thin, subse-

quently it thickens, and then gradually tapers off to end in a free extremity. It is a strong, elastic membrane, distinctly fibrous, especially upon its inner and thicker part.

Membranous Labyrinth. — If the bony labyrinth just described be properly understood, there will not be much difficulty in comprehending the shape of the membranous labyrinth in its interior — a structure supporting the ultimate ramifications of the auditory nerve. It has the general form and shape of the vestibule and the semicircular canals, although smaller, and it is separated from the osseous labyrinth by a quantity of fluid called *perilymph* or *liquor Cotunii*, which is secreted by the delicate serous membrane lying in the bony labyrinth.

The membranous labyrinth is a sac, contained partly in the vestibule and partly in the semicircular canals: that situated in the vestibule is termed the *vestibular portion;* that in the bony canals, the *membranous semicircular canals.*

The sac in the vestibule is so constructed as to form two sacs of unequal size, which indirectly communicate with each other.* The *utricle* or *common sinus*, the larger of the two, is oval and compressed laterally, and communicates with the five openings of the membranous semicircular canals. It is lodged in the fovea hemi-elliptica, and its wall is thickest (*macula acustica*) close to the crista vestibuli, where the branches from the auditory nerve enter it. The *saccule*, the smaller, is globular and flattened, and lies in the fovea hemispherica, in front of the utricle. It is connected with the membranous canal of the cochlea by a small short duct, termed the *canalis reuniens.* From the saccule there passes downwards, along the aquæductus vestibuli, a narrow prolongation, which terminates in a pyriform dilatation, *saccus endolymphaticus;* this canal is joined, at an acute angle, by a short narrow canal from the front of the utricle, so that there is a communication existing throughout the entire length of the membranous labyrinth.

The utricle and the saccule contain on their inner wall a minute mass of calcareous matter in connection with nerve-ends, called by Breschet the *otoliths* or *otoconia.* They are crystals of carbonate of lime, and are present in the labyrinth of all mammalia. From their greater hardness and size in

* From the utricle there proceeds a small canal, which lies in the aquæductus vestibuli; this is joined close to its commencement by a similar canal from the saccule; thus forming the indirect communication above alluded to.

aquatic animals, there is reason to believe that they perform the office of rendering the vibrations of sound sharper and more distinct.*

Membranous Semicircular Canals. — The membranous semicircular canals present the same dilatations or ampullæ as the bony ones at one end, and at this part they nearly fill their bony cases; but in the rest of their extent the diameter of the membranous canal is not more than one-third to one-fifth that of the bony. At the ampullated extremity the sac is connected on its outer aspect by blood-vessels and nerves to the periosteum, forming on section a transverse projection, called the *septum transversum* or *crista acustica*, which forms a partial septum.

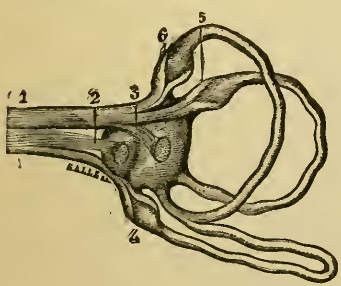


Fig. 317. — Distribution of the Vestibular Branch in the Membranous Labyrinth.

1. Vestibular branch of the nerve. 2. Its branch to the saccule. 3. Its branch to the utricle. 4. Utricular branch to the ampulla of the posterior semicircular membrane. 5. Branch to the external semicircular membrane from the vestibular n. 6. Branch from the same to superior membrane.

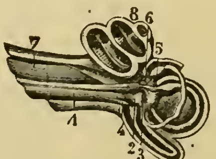


Fig. 318. — The Two Branches of the Auditory Nerve.

1. Vestibular branch. 2. Saccular branch. 3. Utricular branch. 4. Branch to ampulla of posterior membranous canal. 5. Branch to ampulla of external membrane. 6. Branch to superior membrane. 7. Cochlear branch. 8. Cochlea opened to show the distribution of cochlear nerve.

The membranous semicircular canals consist of three layers, an outer or *fibrous layer*, which is connected with the periosteum by blood-vessels, and contains irregular pigment-cells; a middle or *tunica propria*, clear and structureless; and an inner or *epithelial layer*, which lines the inner space of the tunica propria. At the ampullæ the epithelial layer is composed of the columnar variety, upon which are arranged cells of a spindle

* For a detailed description of the relation of the otoliths with the hair-like processes of the nerve-filaments, the student is referred to an article by Dr. Urban Pritchard in the *Quarterly Journal of Microscopic Science*, October 1876, entitled "The Termination of the Nerves in the Vestibule, and Semicircular Canals of Mammals."

shape, having delicate ciliated processes (*auditory hairs*) projecting into the endolymph.

The membranous labyrinth is protected, inside and out, by fluid. The fluid in the interior is termed the *endolymph* or *liquor Scarpæ*, and the thin layer between it and the bone, the *perilymph* or *liquor Cotunnii;* thus the delicate nervous membrane is placed between two layers of fluid.

Distribution of the Auditory Nerve. — The *auditory nerve*, or the eighth cranial nerve, passes down the meatus auditorius internus, and, at the bottom of it, divides into an anterior and posterior branch, which, after breaking up into numerous fasciculi, are distributed to the cochlea and to the vestibule.

The *vestibular nerve* divides into five branches, which proceed to the utricle, the saccule, and the three ampullæ of the semicircular canals, respectively; those for the utricle, and the superior and external semicircular canals enter the vestibule along the crista vestibuli; that for the saccule enters through the fovea hemispherica, and that for the posterior semicircular canal is continued along a bony canal to its termination. The nerves to the semicircular canals enter the ampullæ by a forked swelling which corresponds to each septum transversum.

The *cochlear division* of the auditory nerve is a short, thick branch, which breaks up into numerous filaments at the bottom of the meatus auditorius internus. These enter the canals in the base of the modiolus, and then arch outwards between the plates of the lamina ossea. In their course outwards between the plates, they pass through the spirally arranged ganglionic cord, *ganglion spirale*, beyond which they form a wide plexus. They are collected together close to the free border of the osseous zone, forming a very minute nerve-plexus, whose filaments interlace freely; they then enter the membranous zone to be connected with the inner hair-cells of the organ of Corti.*

The vessels which supply the cochlea are from ten to twelve in number, and are derived from the auditory artery; they, like the nerves, enter the bony canals of the modiolus, and then turn outwards to ramify upon the osseous zone, supplying its periosteum. The plexus formed by these branches communi-

* Some anatomists describe filaments as passing between the rods of Corti to end in the outer hair-cells.

cates with a vessel known as the *vas spirale*, which runs longitudinally in the ligamentum spirale to the outer attachment of the membrana basilaris. The veins from the cochlea terminate in the superior petrosal sinus, having previously joined those of the vestibule and semicircular canals.

DISSECTION OF THE MAMMARY GLAND.

The form, size, position, and other external characters of the mammary gland in the female vary more or less in different persons. The longest diameter of the gland is in a direction upwards and outwards towards the axilla; its thickest part is at the centre, and the fulness and roundness of the gland depend upon the amount of fat about it. Its deep surface is flattened in adaptation to the pectoral muscle, to which it is firmly connected by an abundance of areolar tissue. In its vertical direction the breast corresponds to the space between the third and sixth or seventh ribs; in its lateral direction, to the space between the side of the sternum and the axilla, while the nipple corresponds to the fourth rib, or a little below it.

It is inclosed by a fascia, which not only supports it as a whole, but penetrates into its interior, so as to form a framework for its several lobes; hence, it is that, in cases of mammary abscess, the matter is apt to be circumscribed, not diffused.

The *nipple* (*mammilla*) projects a little below the centre; it is surrounded by a colored circle, termed the *areola;* this circle is of a rose-pink color in virgins, but in those who have borne children of a dark brown. It begins to enlarge and grow darker about the second or third month of pregnancy, and these changes continue till parturition. The areola is abundantly provided with papillæ, and with subcutaneous sebaceous glands, to lubricate the surface during lactation; the areolar, as well as the nipple, is destitute of fat.

Structure. — The gland itself conists of distinct lobes held together by firm connective tissue, and provided with separate lactiferous ducts. Each lobe divides and sub-divides into lobules, and the duct branches out accordingly.* Traced to their origin, we find that the ducts commence in clusters of minute cells, and that the blood-vessels ramify minutely upon these cells; altogether, then, a single lobe might be compared

* It is observed, in some cases, that one or more lobules run off to a considerable distance from the main body of the gland, and lie embedded in the subcutaneous tissue. This should be remembered when it is necessary to remove the entire gland.

to a bunch of grapes, of which the stalk represents the main duct. The main ducts (*galactophorous ducts*) from the several lobes, from fifteen to twenty in number, converge towards the nipple, and, just before they reach it, become dilated into small sacs or *ampullæ*, two or three lines wide; after this they run up to the apex of the nipple, and, running parallel, terminate in separate orifices.

The vesicles and the galactophorous ducts are lined with columnar epithelium, except at their orifices, where it becomes squamous.

The *arteries* of the gland are derived from the long thoracic, the internal mammary, and the intercostals; the *nerves* come from the anterior and lateral cutaneous branches of the intercostal nerves, and from the descending branches of the cervical plexus. The *veins* diverge from the nipple, and terminate in the axillary and internal mammary veins.

The *lymphatics* run chiefly to the axillary glands, but some pierce the front of the intercostal spaces to join the anterior mediastinal glands.

DISSECTION OF THE SCROTUM AND TESTIS.

Scrotum. — The *scrotum* is a pouch of skin for the lodgment of the two testes. They are originally developed in the abdomen, and descend into the scrotum about the eighth month of intra-uterine life. In their descent they push before them certain coverings derived from the strata of the abdominal walls, through which they pass, and which constitute, with the layers of the scrotum, the coverings of the testes. The scrotum presents in the middle a ridge, the *raphé*, on each side of which it is corrugated into transverse folds or *rugæ*. It is divided by a distinct septum into two lateral halves, of which the left is the longer. The scrotum consists of two layers, the integument and the dartos.

The *integument* is of dark color, thrown into transverse rugæ, and provided with sebaceous glands and hairs.

The *dartos* is a thin layer, consisting of muscular fibres of the involuntary kind, like those of the bladder and intestines. It serves to corrugate the loose and extensible skin of the scrotum, and in a measure to support and brace the testes. It is more abundant in the anterior than in the posterior part of the scrotum. Beneath the dartos, and partly intermingling with it, is a large quantity of loose connective tissue, remarkable for the total absence of fat. Together with the dartos, it forms a vertical partition between the testes, termed the *septum scroti*, which passes from the raphé to the under aspect of the penis, as far as its root. It is not a complete partition, since air or fluid will pass from one side to the other. The great abundance and looseness of this tissue explains the enormous swelling of the scrotum in cases of anasarca, and in cases where urine is extravasated into it in consequence of rupture or ulceration of the urethra.

The coverings of the testes, in addition to these *two layers of the scrotum*, are the *intercolumnar* or *spermatic fascia*, derived from the pillars of the external abdominal ring, the *cremasteric fascia*, derived from the lower border of the internal oblique of the abdomen, the *infundibuliform fascia*, derived from the fascia

transversalis, and, lastly, the *tunica vaginalis*, derived from the parietal layer of the peritoneum.

The spermatic fascia, cremaster muscle, and the infundibuliform fascia have been described (pp. 425, 428, 435).

Each of these coverings cannot be demonstrated under ordinary circumstances, because they are so blended together: but they can be shown when hypertrophied in the case of old and large herniæ.

The *arteries* supplying the tissues of the testis are the cremasteric branch of the deep epigastic artery, the superficial and deep external pudic branches of the common femoral artery, and the superficial perineal branch of the internal pudic artery.

The *nerves* are derived from the ilio-inguinal, the genital branch of the genito-crural, the superficial perineal nerves, and the inferior pudendal branch of the lesser sciatic nerve.

The *lymphatics* pass to the inguinal glands.

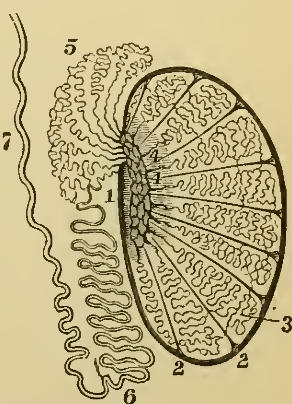


Fig. 319.—Diagram of a Vertical Section Through the Testicle.
1. Mediastinum testis, containing the rete testis. 2,2. Trabeculæ. 3. One of the lobules. 4,4. Vasa recta. 5. Coni vasculosis, forming the "globus major" of the epididymis. 6. Globus minor, or lower end of the epididymis. 7. Vas deferens.

Testis. — The *testis* is a gland of an oval shape with flattened sides, suspended obliquely in the scrotum by the spermatic cord, so that its upper end is directed forwards and upwards, its lower end in the reverse direction. The left is generally a little lower of the two. Each testis is from an inch and a half to two inches (*3.8 to 5 cm.*) in length, an inch in breadth (*2.50 mm.*), and an inch and a quarter (*3.1 cm.*) from behind forwards. Its weight is from six to seven drachms (*23.2 to 27 grm.*), but few organs present greater variations in size and weight, even in men of the same age; generally speaking, the left is the larger. The front and sides of the testis are convex and smooth, and are covered with the visceral layer of the tunica vaginalis; but the posterior surface is only partially invested, as there is here placed a long narrow body, termed the epididymis; this is not a part of the testis, but an appendage to it, formed by the convolutions of its long excretory duct.

The *epididymis* consists of a larger upper end called the

globus major (Fig. 319, 5) and of a lower smaller end, the *globus minor* (Fig. 319, 6), the two being connected together by the *body*. The globus major is connected with the testicle by radiating efferent ducts ; the globus minor is only connected with the organ by connective tissue and the tunica vaginalis. The upper and lower ends and the outer surface of the epididymis are covered with serous membrane, as is also the body, except at its anterior border, where the vessels enter and emerge. Situated between the globus major and the body of the testis are one or two small pedunculated bodies, called the *hydatids of Morgagni ;* they are formed by pouchings of the tunica vaginalis, and are filled with blood-vessels bound together by connective tissue.*

A considerable quantity of unstriped muscular tissue exists at the posterior part of the epididymis and testis beneath the infundibuliform fascia, and has been described by Kölliker as the *inner muscular tissue.*

Coverings of the Testicle. — The testicle is invested by three coverings, which are — 1. A serous membrane, called the *tunica vaginalis,* to facilitate its movements. 2. A strong fibrous membrane, called the *tunica albuginea,* to support the glandular structure within. 3. A delicate vascular stratum, termed the *tunica vasculosa,* which consists of a layer of minute blood-vessels.

The *tunica vaginalis* is a closed serous sac, one part of which, *tunica vaginalis propria,* adheres closely to the testis ; the other, *tunica vaginalis reflexa,* is the reflected portion, adherent to the inner surface of the infundibuliform fascia, and loosely surrounds the testicle. On opening the sac, it will be seen that the *visceral layer* completely covers the testicle, except behind, where the vessels and duct are situated (Fig. 320) ; and that it covers the outer part of the epididymis in front and behind, forming here a pouch called the *digital fossa*. The *parietal layer* extends upwards for a variable distance upon the cord and below the testicle. The interior of the sac is smooth and polished like all other serous membranes, and lubricated by a little fluid. An excess of this fluid gives rise to the disease termed *hydrocele.*

The portion of the process of peritoneum between the internal abdominal ring and the upper part of the tunica vaginalis

* The largest, which lies upon the top of the testis, is stated to be the vestige of the Müllerian duct.

testis (the spermatic portion of the tunica vaginalis) becomes, in the process of development, converted into a fibrous cord, which may usually be recognized, but which is sometimes so atrophied as not to be recognized.

The tunica vaginalis testis was originally derived from the peritoneum. In some subjects it still communicates with that cavity by a narrow canal, and is therefore liable to become the sac of a hernia (Fig. 163, p. 442). Such herniæ are called *congenital* — a misleading term, since they do not necessarily take place at birth, but may occur at any period of life, even in very old age.* Sometimes the communication continues through a very contracted canal, open to the passage of fluid alone; or the communication may be only partially obliterated, and then one or more isolated serous sacs are left along the cord. Such a one, when distended with fluid, gives rise to *hydrocele of the cord.*

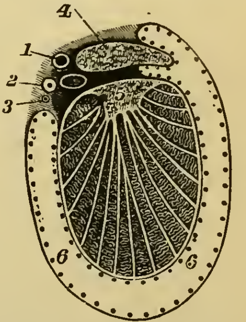


FIG. 320. — TRANSVERSE SECTION THROUGH THE LEFT TESTICLE.
(The dots show the reflections of the tunica vaginalis.)

1. Spermatic artery. 2. Vas deferens. 3. Deferential artery. 4. Epididymis. 5. Mediastinum testis. 6, 6. Cavity of tunica vaginalis.

The *tunica albuginea* is a dense, white, inelastic membrane, composed of white fibrous tissue, interlacing in every direction; analogous to the sclerotic coat of the eye. It completely invests the testis, but not the epididymis. It is covered by the visceral layer of the tunica vaginalis, except behind and at the attachments of the epididymis. At the posterior part of the gland it penetrates into its substance for a short distance, and forms an incomplete vertical septum, termed after the anatomist who first discovered it, *corpus Highmorianum*, and subsequently by Sir A. Cooper, *mediastinum testis* (Fig. 320, 5).

The mediastinum testis transmits the blood-vessels of the organ, and contains also the network of seminal ducts, called the *rete testis*, shown in the diagram (Fig. 319). The septum gives off from its front and sides a number of diverging slender fibrous cords, *trabeculæ testis*,† which traverse the interior of the

* It would be a better term to call this lesion a *hernia in the tunica vaginalis*, denoting thereby its anatomical position; at the same time implying a congenital arrest in development, and without limiting its occurrence to any age of life.

† Kölliker has demonstrated unstriped muscular fibres upon the septa as well as the mediastinum.

gland, and are attached to the inside of the tunica albuginea. They serve to maintain the general shape of the testicle, to support the numerous lobules of which its glandular substance is composed, and to convey the blood-vessels into it. These septa, as well as the mediastinum from which they proceed, are readily seen on making a transverse section through the gland (Fig. 320).

The *tunica vasculosa* (*pia mater testis*) consists of a multitude of minute blood-vessels, formed by the ramifications of the spermatic artery, and held together by delicate areolar tissue. It covers the inner surface of the tunica albuginea, and gives off branches, which run with the fibrous septa into the interior of the gland.

Minute structure. — When the testis is cut into, its surfaces become convex, and present a dirty fawn color. The section is soft and pulpy, and is seen to consist of numerous *lobules*, between two hundred and fifty and four hundred in number,* of various sizes, the central being the larger, and contained in the compartments formed by the fibrous septa proceeding from the mediastinum testis. A few only of these lobules are shown in the diagram. These lobules are conical in shape, their bases being anterior and their apices at the mediastinum, and are bounded by the septa which pass from the mediastinum. They contain two or more minute convoluted tubes, *tubuli seminiferi*, which may be easily unravelled, in consequence of their tough walls. Their number has been estimated to be between 800 and 900, and each has a length of about 18 inches (*35 cm.*) and a diameter averaging $\frac{1}{140}$th of an inch (*.3 mm.*). They commence either by communications with other tubes or by cæcal extremities, and they frequently exhibit small bulgings in their course backwards. The walls of the tubuli consist of a membrana propria, composed of several layers of flattened cells, and the walls are lined with several irregular layers of cells, between which may, under the microscope, be distinguished seminal filaments in various stages of development. The tubuli seminiferi are connected together by a delicate interstitial tissue, the laminæ of which are surrounded by flattened epithelioid cells, and between them are lymph-spaces in direct communication with the lymphatics of the testicle. In this intertubular tissue ramify the minute branches of the spermatic artery which surround the tubules.

* The larger estimate is that by Krause; the smaller, that by Berres.

After pursuing a convoluted course, the tubules unite in front of the mediastinum into from thirty to fifty straight vessels, *vasa recta*, which penetrate the mediastinum testis, and these form an anastomosing plexus of seminal tubes, called the *rete testis* (Fig. 319). This lies along the back of the gland. From the upper part of the rete, its tubes converge to form twelve to fifteen tubes, termed *vasa efferentia*, which perforate the tunica albuginea, and convey the seminal secretion to the upper part of the epididymis. The vasa efferentia are at first straight, but ultimately form a number of coils termed *coni vasculosi*, which collectively constitute the globus major of the epididymis. The coni vasculosi are about $\frac{1}{50}$th of an inch (*.5 mm.*) in diameter, and about $\frac{1}{2}$ to $\frac{2}{3}$ of an inch (*13 to 17 mm.*) long; when unravelled they obtain a length of six to eight inches (*15 to 20 cm.*).

At the globus major the smaller tubes terminate in a single duct, the *canal of the epididymis*, which in its descent describes an extremely tortuous coil, constituting the body and globus minor of the epididymis. The length of the canal of the epididymis is, in its natural condition, about three inches (*7.5 cm.*), but when unravelled it is nearly twenty feet (*6 m.*) in length. The diameter of the canal is about $\frac{1}{70}$th of an inch (*.4 mm.*). It is lined with columnar ciliated epithelium.

Vas Deferens. — The *vas deferens* begins at the lower part of the globus minor; at first it is somewhat convoluted, but, as it ascends behind the epididymis, it becomes subsequently straight, and joins the other component parts of the cord. After passing through the inguinal canal, it enters the abdomen through the internal ring. It then winds round the outer side of the deep epigastric artery, and, after crossing over the external iliac artery and vein, it enters the pelvis, curves round the side and lower part of the bladder, and empties itself into the prostatic part of the urethra, after running a course of about two feet. Its course in the abdomen has been previously described (p. 521). Its length is two feet (*60 cm.*) and its diameter $\frac{1}{10}$th of an inch (*2.5 mm.*).

In connection with the anterior aspect of the cord, just above the epididymis, are two or three small masses of convoluted tubes, which are known as the *organ of Giraldès*, or the *parepididymis*. They are lined with squamous epithelium, and are probably the remains of part of the Wolffian body.

The *vas aberrans* is a small convoluted tubule, with a cæcal

extremity, found between the epididymis and the cord, and communicating usually with the canal of the epididymis. It is about an inch (*2.5 cm.*) in length, but, when frayed out, varies from two to twelve inches (*5 to 30 cm.*) in length. It, like the organ of Giraldès, is connected with a fœtal structure — the Wolffian body.

The vas deferens consists of an external or connective-tissue coat; a middle or muscular coat, composed of longitudinal and circular fibres intermingled with elastic tissue; and an internal or mucous coat, arranged in longitudinal folds, and lined with columnar epithelium. It can always be recognized from the other constituents of the spermatic cord by its hard whipcord-like feel.

Spermatic Cord. — The *spermatic cord* begins at the interal ring, traverses the inguinal canal, and extends to the testis, where its component parts pass to their respective destinations. It is composed of the spermatic vessels, nerves, and lymphatics; of the vas deferens, with the deferential artery, a branch of the superior vesical; of the cremaster muscle and the cremasteric artery, a branch of the deep epigastric. The coverings of the cord have been described, with the anatomy of the parts concerned, in inguinal hernia (p. 440).

The *spermatic artery* in its course along the cord becomes remarkably tortuous; it enters the back part of the testicle, and breaks up into a number of fine ramifications, which spread out on the inner surface of the tunica albuginea.

The *spermatic veins* leave the testis at its back part, and, as they ascend along the cord, become extremely tortuous and form a plexus, termed the *pampiniform plexus.* They lie in front of the vas deferens and unite to form a single vein, which on the right side opens into the inferior vena cava, and on the left side into the left renal vein. It is usually stated that these veins are destitute of valves; and this fact is adduced as one of the reasons for the occurrence of varicocele. It is, however, certain that the larger veins do contain valves.

The *lymphatic* of the testis pass through the lumber glands; hence these glands, and not the inguinal, become affected in malignant diseases of the testis.

The *nerves* of the testicle are derived from the sympathetic. They descend from the abdomen with the spermatic arteries, and come from the aortic and renal plexuses, with a few filaments from the hypogastric plexus, which surround the defer-

ential artery (p. 526). This accounts for the ready sympathy of the stomach and intestines with the testicle, and for the constitutional effects of an injury to it.

Descent of the Testis. — The testicle is originally developed in the lumbar region, immediately below the kidney, and is loosely attached to the back of the abdomen by a fold of peritoneum, termed the *mesorchium*, along which its vessels and nerves run up to it, as to any other abdominal viscus. From the lower end of the gland a fibrous cord, termed the *gubernaculum testis*,* proceeds to the bottom of the scrotum. There is no evidence to warrant the assumption that the gradual eontraction of the gubernaculum effects the descent of the testis The organ begins to descend from the lumbar region about the fifth month of fœtal life, reaches the internal ring about the seventh, and about the ninth has entered the scrotum. Its original peritoneal coat is retained throughout ; but as it enters the inguinal canal the peritoneal lining of the abdomen is pouched out before it, and eventually becomes the tunica vaginalis reflexa. Immediately after the descent of the testis its serous bag communicates with the abdomen, and in the lower animals continues to do so throughout life.† But in the human subject the canal of communication soon begins to close. It closes at the upper extremity first,‡ and the closure is generally complete in a child born at its full time.§ This provides against the occurrence of rupture, to which man, owing to his erect position, is more exposed than animals. At the end of the first month after birth the canal is entirely obliterated from the internal ring of the testis. Sometimes, however, this obliteration fails, or is only partial ; hence may arise congenital hernia,

* Mr. Curling considers the gubernaculum testis to be a muscular cord. See his "Observations on the Structure of the Gubernaculum, and on the Descent of the Testis in the Fœtus," *Medical Gazette*, April 10, 1841. This is denied by Cleland. See "Mechanism of the Gubernaculum Testis," 1856.

† According to Professor Owen, the African orang-outang (*Simia troglodytes*) is the only exception to this rule. In this animal it is interesting to observe that the lower extremities are more fully developed as organs of support, and there is a ligamentum teres in the hip-joint.

‡ The frequency of hernia in the funicular portion of the vaginal process of the peritoneum hardly bears this out.

§ Camper has shown that the canal on the right side is nearly always open at birth, whereas that on the left is usually closed. This explains the greater frequency of hernia on the right side in children under one year old. Thus out of 3,014 cases of inguinal hernia seen at the City of London Truss Society under one year 2,269 occurred on the right side and 745 on the left ; or in the proportion of 3 to 1.

or hydrocele. The possible existence of a communication between the tunica vaginalis and the peritoneal cavity of the abdomen is one reason, among many, why caution should be observed in treating hydroceles in children with stimulating injections.

HEWSON'S ANOMALY BLANK.*

Student's Name, ...

Note Anomalies or variations (after referring to Morris's Anatomy), and have the same verified by a demonstrator who signs this card. When examined on the part, this blank is to be returned to Dr. , Demonstrator of Anatomy, Medical College.

Table No. , ***A. B.*** ; ***Sex,***

Prob. Age, ; ***Color,***

Bones.

Muscles.

Arteries.

Veins.

Nerves.

Viscera.

Peritoneum.

Pericardium.

Pleura.

I have examined the above specimen and report it correct.

....***M. D.,***
Demonstrator.

* On the reverse side is space for the student to make a drawing. The original size of this chart is 9½ x 6 inches.

EXPLANATION OF BLANK.

THE blank on opposite page has been used by the editor with so much success that it is given here as a suggestion to other teachers who do not keep any record of anomalies.

The object of this blank is twofold: first, to obtain a verified record of anomalies; second, as an educator in preparing the student to put into words what he sees. What is not so well expressed by description may be thoroughly done by a drawing. In recording the number of the table I can inquire of other students on the same body whether any anomalies were present.

A. B. After this is placed the number given to the body by the Anatomical Board, by means of which any history may be traced.

The other points in the blank need no illumination.

The reason Morris's Anatomy is referred to is because the "Variations" are so specifically marked and are more easily found by the student than in any other work.

The rigid examination held after each part has been dissected, has done much to stimulate the student to work carefully and note what he finds.

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